Desk

VOLUME LIII NUMBER 6 WHOLE 467

SCHOOL SCIENCE AND MATHEMATICS

JUNE 1953

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis. PRICE. Four dollars and fifty cents a year; foreign countries $5.00; current single copies 75 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.

Summer vacation for teachers. For some it is a time for travel, to see new places and meet different people; others will want to read or write, study plants, animals, or minerals in their native haunts; for some it is an opportunity to do additional study toward a higher degree or for pursuit of a favorite topic of research; for a few it should be a time for complete rest and physical repair. But a vacation is not always a time to take on another teaching job. Be sure that you get a real vacation part of the year, both for yourself and for the welfare of your pupils.

CONTENTS FOR JUNE, 1953

SCHOOL SCIENCE AND MATHEMATICS

VOL. LIII | JUNE, 1953 | WHOLE NO. 467

SEASHORE SHELL LIFE OF THE NORTHWEST

B. CLIFFORD HENDRICKS
Longview, Washington

"Oysters have eyes," says Eldon Griffin,[1] "As the microscopic (oyster larva) moves around in the water during the weeks following his quiet birth . . . the only guidance he gets . . . is supplied by a very simple 'eye' or photosensitive cell. When its work is done this modest mechanism retires from the oyster's life."

Clams may be said to have feet. There is but one foot for each clam, however, and it is called a digger rather than a foot. This member of clam's anatomy is responsible for his movement. "Rapid movement is the razor clam's chief protection from man," say those who know.[2] "Its shell is slender and thin and has a flexible laquer-like coating. This combined with its powerful digger, enables it to submerge several feet (through wet sand) at the rate of up to nine inches a minute."

It may not have been asked upon radio-quiz programs but that doesn't mean that it is not in order. "When is a crab not a crab?" The answer is: "When it is a hermit crab." "In the strictest sense of the word," says William Crowder,[3] "the hermit crab is neither a hermit nor is it a crab. . . ." (His) shell's resemblance to the shelter of a hermit is no more analogous than that the shirt on one's back is one's home. Nor is he averse to the company of his fellows. At no time does he lead a life of seclusion. . . . True crabs belong to a classification labelled by a word, Brachyura, meaning 'short bellied crustacean.' Actually this hermit crab has neither a long or short belly and has, for that reason, been labelled, by some authorities, the nameless bellied, Anomura."

---

[1] Griffin, Eldon, "Travels of a Pacific Oyster," p. 2. Wilberlilla Pub. Seattle, Washington.
[2] Washington State, "Shellfish," p. 4. State Dept. of Fisheries, Gig Harbor, Washington.
[3] Crowder, William, "The Dwellers of the Sea and Shore," pp. 89–90. Macmillan Co., New York.

Shell Fishing not a Shell Game

Shellfish are more than objects of novelty in the Northwest. In a 1940 roll call of states, Washington stood second in line, rated in terms of canned oyster pack. It was outstripped by Mississippi whose 291,100 cases more than doubled Washington's 129,319. While Washington's pack was only 44.5% that of Mississippi, its value, in dollars, was 45.5% that of her rival.

A census of fishery products landed at Seattle, in 1940, listed: clams, over 1000 tons; crabs, over 2000 tons and oysters, slightly less than 1000 tons. However, the value of the oyster take was 66.5% of the crab harvest though its quantity was but 43.0% of the crabs. With these "big three" there should be mention of shrimps though that shellfish does not compare in quantity production with the other three. Its yield, also, seems to be on the decline.

The Indians Shelled Oysters Too

In terms of cultivation and development the oyster industry appears to have greater promise than the other shellfish resources. Historically, oysters were extensively used by the Indians "long before the day of the white man."[4] It was the first shell-food to receive attention from explorers. "Nearly a century ago . . . when American ships from California put in (at Willapa Bay) to load piling . . . for the rising port of San Francisco, they found a new and unexpected kind of gold mine in the fine oysters that were to be had for the taking."[5]

The oysters the Californian voyagers found were what are currently called the Olympia oyster. It is native to the northwest coast. It is relatively small, about two inches in greatest dimension, but is regarded, by reason of "a remarkably delicate flavor, . . . (as) one of the choicest sea foods on the market."[6]

Oyster Immigrants

These native oysters, upon most of the areas where first found, were exploited to virtual extinction. Fortunately, for the industry, "a new species of oysters which is of far greater commercial significance"[7] was introduced from Japan in the early years of the 1890's. This importation grew to great magnitude by the year 1929. The procedure is to catch "oyster seeds (larvae) on . . . shells (and ship them) in boxes from Japan each spring. . . . (Rather) remarkably, . . . when planted in Washington waters, these . . . (seed) grow and

[4] Washington State, "Oyster Culture," p. 5. Secretary of State, Olympia, Washington.
[5] Griffin, Eldon, *op. cit.*, p. 5.
[6] Oyster Culture, *op. cit.*, p. 5.
[7] Oyster Culture, *op. cit.*, pp. 5–6.

develope two or three times more rapidly than they do in their original home waters."[8]

The Japanese imported oyster is known, in the United States, as the Pacific oyster. "If left for three or four years it will grow . . . to an extremely large size. Some . . . may be as much as sixteen or eighteen inches long and several inches wide. Ordinarily, . . . they are marketed at a much smaller size because of . . . greater tenderness and more delicate flavor."[9]

Oyster Farms

"(Oyster farming) is not so simple as it may seem. . . . (There is more to it than) plant the seeds and . . . wait for them to grow to market size. (The fact that) it is unnecessary to provide any food for the crop" may be why oyster farming is mistakenly rated a loafer's job. There is a sort of series of tasks that confront the oyster-cropper year in and year out: plotting the tide-land for seeding; planting the seed; spreading the growing oysters over the bed so they are able to feed and fatten effectively; and finally the picking either by hand or by tongs. The "last round up" for the oyster is staged at the cannery. That, however, may be considered beyond the oyster farmer's responsibility.

Some Eat 'Em Alive

"Oysters . . . are the only animals . . . intentionally eaten alive. . . . This is a valuable asset because we are able to absorb the minerals and vitamins . . . unchanged by cooking."

A newer method of canning makes the claim that "for the first time . . . (one is able) to buy canned oysters full sized, rich and white. . . . Steam canning does not remove the glycogen. The meats, therefore, retain that rich, solid fatness . . . so highly valued in the fresh oyster."[10] So the oyster farmers of the Northwest look to the future with confidence.

Festival Fritters

Summer resort season opened mid-May at Long Beach, Washington, in 1952, by a free clam meal for all comers. Tasty clam fritters were fried "while you wait" in a pan said to be the world's largest. It measures nine feet across and is fourteen inches deep; it weighs 550 pounds. East coast beach parties have their clam bakes; the west seems to cater to clam fries.

One of the attractions to vacationers, on the west coast, is they may "dig their own." Evidence that many diggers get into the act

[8] Oyster Culture, *op. cit.*, p. 6.
[9] Oyster Culture, *op. cit.*, p. 11.
[10] Oyster Culture, *op. cit.*, p. 12.

can be implied from the issuance of the 1953 "Razor Clam Diggers' Rules," in early March. These rules restrict commercial diggers both as to size of clams dug and days of week on which they may be taken. Sports diggers are limited as to the number they may take but not as to the days when they may be obtained.

The most interesting part of a clam's anatomy is its foot or digger. "The digger has a sharp, rigid tip. When quickly extended into the sand, a series of foot muscles force water into it, flaring out the tip like the head of a nail. With this as an anchor the clam pulls itself downward with a second set of muscles. It is able to (move) . . . vertically with ease (but) . . . does not migrate between areas to (any) extent."[11]

Wanderers of the Deep

In contrast with clams, crabs do "go places." One specimen released near Westport, Oregon was later captured eighty miles away at Tillamook bay. Most members of this shell group, however, seem to be less ambitious in their movements, averaging ten to fifteen miles. They move from the deep to the shallow shore waters of the coast.

Also unlike either oysters or clams, the crabs shed their exterior skeletons as they grow from the one and one half inch back-width of the yearling to the eight to ten inch size of the adult males. As would be expected, moulting occurs more frequently the first year than during the later part of its life.

In fishing for crabs, which are mostly (95%) caught in the ocean off-shore, crab pots are used. These screened-in traps have hinged doors which the crabs push open in order to get at the bait. Once in, the door automatically closes and the crab's next trip is to the water's surface as the fisherman lifts the pot.

The crab for which there is the greatest demand is the Dungeness. These are marketed both as fresh and canned crab meat. The peak production year for Washington, in 1942, recorded 26,052 pounds valued at about $1,000,000.

A Shell's Sermon

Shell life may attract man's attention from various points of view. He may look to it as a source of livelihood; it may intrigue his curiosity or it may, as for Oliver Wendell Holmes, stir to poetic insights. Very well and appreciatively known is his last verse of "The Chambered Nautilus":

"Build thee more stately mansions, O my soul!
As the swift seasons roll!
Leave thy low-vaulted past!

---

[11] "Shellfish," *op. cit.*, p. 4.

Let each new temple, nobler than the last,
Shut thee from heaven with a dome more vast,
Till thou at length art free,
Leaving thine outgrown shell by life's unresting sea!"

PREPARING OUR STUDENTS FOR THE SCIENTIFIC AGE

Rogers E. Randall
Southern University, Baton Rouge, Louisiana

Science to the average student seems to be a chore. He thinks it is uninteresting and is merely designed for the genius. In cases where survey science courses are being offered the average student has an idea that it must be a "do-nothing" course. Before a science course—pure or survey—can be effectively taught, the interest of the students must be obtained if the student is expected to learn any scientific principles or facts or appreciate the course.

In the opinion of the writer, this interest in science should begin in grade school. Dr. Charles A. Prosser's resolution[1] seems to have started the development of the life adjustment movement. It was pointed out that only 80 per cent of our youth enter the ninth grade and only 50 per cent remain to be graduated from high school.[2]

If we in the field of science education are going to prepare our students for this scientific age, all of our science courses (not gadgetry) must be geared to meet their present needs.

The interest of our students can be successfully increased if administrators and teachers endeavor to give them a point of view that science is important regardless of their chosen fields. It appears that a good survey course in the physical as well as the biological sciences may serve well for the liberal education of all students.

Colleges and universities must produce teachers and students of science with a decent concept of what science is. The prospective teacher of science must have more than just the fundamentals of how to teach science. They need also an understanding of the science principles, facts, and concepts. Prospective teachers of elementary and secondary education should be convinced that a good survey course in the physical and biological sciences will aid them in doing a better job with small children—giving them correct information in answer to their inquiries about the physical world. In addition, colleges and universities must help prospective teachers and students of science to develop an attitude of learning for learning's sake and teaching for teaching's sake.

---

[1] Douglas, Harl R., *Education For Life Adjustment*, The Ronald Press Company, 1950, Chapter 1.
[2] *Ibid.*

Our public schools can play a great part in obtaining the interest of students in science, and encourage more of them to attend college where they may get better facilities to specialize in any desired area of science. For those students who do not plan to specialize in science, our high schools can do a good job preparing them to appreciate the basic principles of science.

Individuals who dislike science courses in general might argue that it is a waste of time to have non-science majors studying any course in science. However, one should observe that science makes contributions to the adjustment of individuals. The following are suggestions:[3]

1. Science can aid in the development of the social competence of individuals.
2. Science can aid in the development of the physical and mental health of individuals.
3. Science can aid in the education of individuals as potential consumers.
4. Science can aid in the education of the individual in developing a philosophy of living.
5. Science can aid in the education of the individual for maintaining personal safety.
6. Science can aid individuals in developing a desirable group of attitudes.
7. Science can aid individuals in developing a pattern of appreciations.

Administrators in education should plan as soon as the situation permits to avoid the practice of having non-science trained teachers teaching courses in science. Dr. J. Warren Lee cited in his study[4] that of the natural science teachers observed in Louisiana, 15 per cent were certified in home economics, 10 per cent in elementary education, 7.5 per cent in social science, and 2.5 per cent in health and physical education.

So then, if our students are to be prepared for this scientific age, teachers of science must (1) maintain enthusiasm in the science course they are teaching, (2) do a good job in teaching and methodology as a means of increasing students' interest in science, (3) strive to keep and maintain laboratories in science courses where laboratories are required, and (4) do a conscientious job in preparing our students to obtain the scientific spirit and an appreciation of things scientific.

[3] Heiss, Edward D., *Modern Science Teaching*, New York, The Macmillan Company, 1950, p. 16.

[4] Lee, J. Warren, "Status of the Natural Science Teacher In Negro High Schools in Louisiana." *Science Education*, Febuarry, 1950.

POLIO FOUGHT IN MEXICO WITH GAMMA GLOBULIN

Mexico launched a campaign to collect blood for gamma globulin, March 2, in an effort to control infantile paralysis in that country.

The gamma globulin will be given to children under five years of age, in areas where polio danger is acute, reported a national committee of physicians and scientists that is taking charge of the blood drive.

THE STRENGTHS OF THE OXYGEN ACIDS

LINUS PAULING
California Institute of Technology, Pasadena, Calif.

A considerable part of the elementary course in chemistry is devoted to acids and bases and their properties. Students are interested to learn that acids are not all alike in their acidity—that there are extremely weak acids, such as boric acid and silicic acid, moderately weak acids, such as acetic acid and phosphoric acid, and strong acids, such as sulfuric acid and perchloric acid.

I remember that I was surprised, twenty years ago, that one of my students, Charles Coryell, who is now Professor of Chemistry in the Massachusetts Institute of Technology, had the unusual power of remembering the strengths of all of the common acids. I myself at that time was not able to remember that phosphoric acid is a weak acid, whereas sulfuric acid is a strong acid and silicic acid is a very weak acid. A few years later, however, I was led to formulate a simple set of rules by means of which the strengths of the oxygen acids can be easily remembered. These rules are described in the following paragraphs.

On 11 October 1935 I gave a talk before the undergraduate chemistry club of the California Institute of Technology, on the subject "How to Tell an Acid from a Base." In this talk it was pointed out that the electronic structures of silicic acid, phosphoric acid, sulfuric acid, and perchloric acid are such as to explain in a reasonable way the fact that silicic acid is a very weak acid, phosphoric acid is a weak acid, sulfuric acid is a strong acid, and perchloric acid is a very strong acid. Shortly thereafter I noted that the same structural explanation could be extended to include other oxygen acids, such as sulfurous acid, in which the central atom does not have its maximum oxidation number. The rules were published for the first time in a preliminary edition of my textbook "General Chemistry," printed in 1941 for use by the freshman students in the California Institute of Technology. They were then included in the first edition of "General Chemistry," W. H. Freeman and Company, San Francisco, 1947, and in "College Chemistry," W. H. Freeman and Company, 1950.

The rules are so simple and straightforward that students accept them without question, and make use of them in their further study of chemistry.

Let us first consider the formulas of the oxygen acids of the electronegative elements in their highest oxidation states. These formulas are given in Table 1.

TABLE 1

H_3BO_3 Boric acid	H_2CO_3 Carbonic acid	HNO_3 Nitric acid		
	H_4SiO_4 Silicic acid	H_3PO_4 Phosphoric acid	H_2SO_4 Sulfuric acid	$HClO_4$ Perchloric acid
	H_4GeO_4 Germanic acid	H_3AsO_4 Arsenic acid	H_2SeO_4 Selenic acid	$HBrO_4$ Perbromic acid
	$H_2Sn(OH)_6$ Stannic acid	$HSb(OH)_6$ Antimonic acid	H_6TeO_6 Telluric acid	H_5IO_6 Periodic acid

It is seen that the ligancy (coordination number) of the centra atom changes from 3 for the first-row atoms to 4 for the second-row and third-row atoms and to 6 for the fourth-row atoms. This change in ligancy can be easily understood by consideration of the sizes of the atoms. The first-row atoms, boron, carbon, and nitrogen, are so small that only three oxygen atoms can be fitted around them; a fourth oxygen atom, at the fourth corner of a tetrahedron around the central atom, would be brought into too close approximation to the other three to result in a stable structure. The second-row and third-row atoms are larger, and can accommodate four oxygen atoms at the corners of a tetrahedron about the central atom. The still larger fourth-row atoms can hold six oxygen atoms about themselves, at the corners of an octahedron.

The acids in which the central atom has oxidation number 2 less than for these acids have similar structures, with, however, one oxygen atom missing, and replaced by an unshared electron pair on the central atom. These acids include nitrous acid, HNO_2; phosphorous acid, H_3PO_3; sulfurous acid, H_2SO_3; and chlorous acid, $HClO_2$. The class of acids in which the central atom has oxidation number still smaller by 2 includes hyponitrous acid, $H_2N_2O_2$; hypophosphorous acid, H_3PO_2; and hypochlorous acid, HClO.

The strength of an acid can be expressed by its ionization constant. The equilibrium constant for the ionization reaction

$$HA + H_2O \rightleftarrows H_3O^+ + A^-$$

is

$$K = \frac{[H_3O^+][A^-]}{[HA][H_2O]}\,.$$

It is customary to suppress the concentration of water, which is essentially constant, and to write for the acid constant, K_a, the equation

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}.$$

The strengths of the oxygen acids are expressed approximately by the following two rules:

Rule 1. The successive acid constants K_1, K_2, K_3, . . . of a polyprotic acid are in the ratios $1:10^{-5}:10^{-10}$. . . . These successive acid constants are the first ionization constant for an acid, its second ionization constant, its third ionization constant, etc. For phosphoric acid, for example, the first ionization constant has the value 0.75×10^{-2}, the second 0.62×10^{-7}, and the third 1×10^{-12}. The first constant corresponds to the reaction

$$H_3PO_4 + H_2O \rightleftarrows H_3O^+ + H_2PO_4^-.$$

The second constant corresponds to the reaction

$$H_2PO_4^- + H_2O \rightleftarrows H_3O^+ + HPO_4^{--}.$$

The third constant corresponds to the reaction

$$HPO_4^{--} + H_2O \rightleftarrows H_3O^+ + PO_4^{---}.$$

We see that these three constants are very closely in the ratio $1:10^{-5}:10^{-10}$.

For sulfurous acid the first and second constants have the values 1.2×10^{-2} and 1×10^{-7}, which are again in the ratio $1:10^{-5}$. It is found that this rule, that each ionization constant of an acid is 100,000 times smaller than the preceding one, holds well for all of the acids of the class under consideration.

Rule 2. The value of the first ionization constant is determined by the formula of the acid, written as $XO_m(OH)_n$: if m is zero (no excess of oxygen atoms over hydrogen atoms, as in $B(OH)_3$) the acid is very weak, with $K_1 \leqq 10^{-7}$; for $m=1$ the acid is weak, with $K_1 \cong 10^{-2}$; for $m=2$ the acid is strong, with $K_1 \cong 10^3$; for $m=3$ the acid is very strong, with $K_1 \cong 10^8$.

It is interesting that the same factor, 10^{-5}, occurs in this rule as in Rule 1.

The application of the rule is shown by the constants given in Table 2.

The first rule can be understood as reflecting the increase in electric attraction of the negative ion for the positive proton, with increase in the degree of ionization.

An easy explanation of the second rule can be given by the follow-

TABLE 2

First class: Very weak acids $X(OH)_n$ or H_nXO_n		
First acid constant about 10^{-7} or less		
		K_1
Hypochlorous acid, $HClO$		9.6×10^{-7}
Hypobromous acid, $HBrO$		2×10^{-9}
Hypoiodous acid, HIO		1×10^{-11}
Silicic acid, H_4SiO_4		1×10^{-10}
Germanic acid, H_4GeO_4		3×10^{-9}
Boric acid, H_4BO_3		5.8×10^{-10}
Arsenious acid, H_3AsO_3		6×10^{-10}
Antimonous acid, H_3SbO_3		10^{-11}
Second class: Weak acids $XO(OH)_n$ or H_nXO_{n+1}		
First acid constant about 10^{-2}		
		K_1
Chlorous acid, $HClO_2$		10^{-2}
Sulfurous acid, H_2SO_3		1.2×10^{-2}
Phosphoric acid, H_3PO_4		0.75×10^{-2}
Phosphorous acid, H_2HPO_3		1.6×10^{-2}
Hypophosphorous acid, HH_2PO_2		1×10^{-2}
Arsenic acid, H_3AsO_4		0.5×10^{-2}
Periodic acid, H_5IO_6		2.3×10^{-2}
Nitrous acid, HNO_2		0.45×10^{-3}
Acetic acid, $HC_2H_3O_2$		1.80×10^{-5}
Carbonic acid, H_2CO_3		0.45×10^{-6}
Third class: Strong acids $XO_2(OH)_n$ or H_nXO_{n+2}		
First acid constant about 10^3		
Second acid constant about 10^{-2}		
	K_1	K_2
Chloric acid, $HClO_3$	Large	
Sulfuric acid, H_2SO_4	Large	1.2×10^{-2}
Selenic acid, H_2SeO_4	Large	1×10^{-2}
Fourth class: Very strong acids $XO_3(OH)_n$ or H_nXO_{n+3}		
First acid constant about 10^8		
Perchloric acid, $HClO_4$	Very strong	
Permanganic acid, $HMnO_4$	Very strong	

ing argument. Let us consider the acids $HClO$, $HClO_2$, $HClO_3$, and $HClO_4$. According to the second rule the first acid, hypochlorous acid, should be a very weak acid, the second acid, chlorous acid, should be a weak acid, the third acid, chloric acid, should be a strong acid, and the fourth acid, perchloric acid, should be a very strong acid. If hypochlorous acid, $HClO$, ionizes, the negative ion that is formed, ClO^-, has its negative charge concentrated on a single oxygen atom. The force of attraction of the proton to this oxygen atom would be characteristic of the force that leads to the formation of an O—H valence bond. Now let us consider chlorous acid. In the chlorite ion, ClO_2^-, the negative charge is divided between two oxygen atoms, and as the proton approaches one of the oxygen atoms, in the formation of the O—H bond in chlorous acid, the attraction would be

expected to be smaller than in the case of hypochlorite ion. The acid constant for chlorous acid would accordingly be expected to be larger than that for hypochlorous acid. Similarly in the chlorate ion, ClO_3^-, formed by ionization of chloric acid, the total negative charge would be divided among the three oxygen atoms, and the attraction of one of the oxygen acids for an approaching proton would be still smaller, corresponding roughly to that for one third of a negative charge, rather than for one half of a negative charge for the chlorite ion and one negative charge for the hypochlorite ion; this would be expected to cause chloric acid to be a still stronger acid than chlorous acid. The same argument leads us to expect perchloric acid to be still stronger than chloric acid.

It is seen that all of the acids listed in the first section of Table 2 have one hydrogen atom for every oxygen atom: their formulas are of the types $Cl(OH)$, $As(OH)_3$, and $Si(OH)_4$.

In the second part of Table 2, the class of weak acids, with first acid constant about 10^{-2}, there are several acids in which the number of hydrogen atoms is one less than the number of oxygen atoms. These include acids such as chlorous acid, $ClO(OH)$; sulfurous acid, $SO(OH)_2$; phosphoric acid, $PO(OH)_3$; and periodic acid, $IO(OH)_5$.

There are also given in this class two acids, phosphorous acid and hypophosphorous acid, which seem to be out of place, inasmuch as their formulas, H_3PO_3 and H_3PO_2, seem not to put them in this class. Their acid constants, 1.6×10^{-2} and 1×10^{-2}, respectively, are, however, appropriate to the class, and an explanation must be sought for the apparent abnormality. The explanation is that one of the hydrogen atoms in phosphorous acid is bonded directly to the phosphorus atom, and two of the hydrogen atoms in hypophosphorous acid are bonded to the phosphorus atom. The correct structural formula of phosphorous acid is $HPO(OH)_2$; this formula shows that the phosphorus atom has, in addition to a hydrogen atom directly bonded to it, one oxygen atom and two hydroxyl groups bonded to it. The structural formula for hypophosphorous acid is $H_2PO(OH)$; in this acid the phosphorus atom has two hydrogen atoms and one oxygen atom bonded to it, as well as one hydroxyl group. There is independent evidence of several sorts, obtained from physical chemical experiments, to show that in these acids there are hydrogen atoms bonded directly to phosphorus. The ions of these acids—phosphite ion, HPO_3^{--}, and hypophosphite ion, $H_2PO_2^-$—represent intermediate structures between the phosphate ion, PO_4^{---}, and the phosphonium ion, PH_4^+. In each of these ions there is a phosphorus atom bonded to four other atoms, hydrogen or oxygen, which surround it tetrahedrally. One structure is missing, that of phosphine oxide, H_3PO; this substance seems to be too unstable to exist, although

analogs of it, such as the substituted phosphine oxides, R_3PO, and the oxyhalides, such as Cl_3PO, are known.

It may be seen that nitrous acid, acetic acid (as well as the other carboxylic acids), and carbonic acid deviate somewhat in the values of their acid constants from the simple rule. The deviation for nitrous acid and the carboxylic acids can be attributed to their electronic structure—the tendency of first-row atoms to form stable double bonds more easily than heavier atoms. For carbonic acid the low value of the first acid constant is due in part to the existence of some of the unionized acid in the form of dissolved CO_2 molecules rather than the acid H_2CO_3. It has been found that the ratio of the concentration of dissolved CO_2 molecules to H_2CO_3 molecules is about 25, so that the true acid constant for the molecular species H_2CO_3 is about 2×10^{-4}.

Students may ask how it is known that the first acid constant for sulfuric acid is about 10^3. One answer that can be given to this question is that the second acid constant, the acid constant for HSO_4^-, has the value 1.2×10^{-2}, as found by, for example, measuring the *p*H of a solution containing equiformal amounts of the salts $NaHSO_4$ and Na_2SO_4. Our first rule then indicates that the first acid constant of sulfuric acid would be 10^5 times larger, that is, equal to 1.2×10^3. There have also been developed direct methods of estimating the strengths of strong acids and very strong acids, by the use of nonaqueous systems.

Oxygen acids which do not contain a single central atom have strengths corresponding to reasonable extensions of the rules, as shown by the following examples:

	K_1	K_2
Very weak acids: $K_1=10^{-7}$ or less		
Hydrogen peroxide, HO-OH	2.4×10^{-12}	
Hyponitrous acid, HON-NOH	$9\ \times10^{-8}$	$1\ \times10^{-11}$
Weak acids: $K_1=10^{-2}$		
Oxalic acid, HOOC-COOH	5.9×10^{-2}	6.4×10^{-5}

It is seen that in the case of hyponitrous acid and oxalic acid the second ionization constant is only about 10^{-3} times the first one, rather than 10^{-5}, as in the case with acids with a single central atom. The larger value of the second ionization constant for these acids can be explained as resulting from a smaller effect of the negative charge produced by the first ionization, because of its larger distance from the second hydroxyl group that is undergoing ionization.

The arguments that have been presented to explain the two simple rules that represent reasonably well the observed strengths of the oxygen acids do not in fact account for the simple form of these rules.

We may consider that it is a fortunate circumstance that the successive ionization constants for a single polyprotic acid have the same ratio, 10^{-5}, and also that the first ionization constants for oxygen acids of the various sorts discussed in Table 2 have the same ratio, 10^{-5}, which happens also to be equal to the ratio for the first rule. It is this fact that has made it possible to summarize the acid constants in such a simple way, and that makes the two rules easily remembered and easily used, without confusion.

WEST MUST KEEP TECHNICAL WEAPON SUPERIORITY

The tools of war produced by the west must retain their margin of superior effectiveness over those of the communistic world, if it is to survive in the face of the latter's overwhelming population advantage.

"Once the technical margin between the two worlds disappears, the west is on its way to defeat," said Frank W. Godsey, Jr., general manager of the Baltimore, Md., Divisions of Westinghouse Electric Corporation. He was addressing 600 members of the Congress of Civil Aviation Conferences Meeting in Kansas City, Mo.

Mr. Godsey was one of a series of aviation authorities who addressed the three-day session held in celebration of the fiftieth anniversary of powered flight.

Mr. Godsey, whose responsibilities include the Baltimore Air-Arm plant as well as the Electronics and X-Ray Divisions, took issue with those who claim our modern aircraft equipment, controls, armament and radar systems are becoming so complex that they are more a hindrance than a help to our flyers.

"True, many of these could be eliminated," he said, "But the peril of not carrying such equipment must constantly be weighed against the slightness of the penalties of carrying them all the time."

Mr. Godsey cited the twin-jet fighter, F3D, which carries one-half ton of radar equipment as an example of a ship whose value lies in its equlpment rather than in its speed.

"The combination of radar and armament in the F3D Sky Knight is helping this plane set combat records in Korea," he said. "Against the simpler, lighter and much faster MIG, this plane has piled up a score that proves its radar gear is paying off."

"Of course the multiplicity of electronic equlpment allows the pilot to use it for more purposes than the sighting and shooting down of the enemy. With the addition of a few necessary gadgets it can be used for navigational purposes. If you don't think this is desirable, just ask one of our pilots," he said.

NEW ALLOY SAVES SCARCE BERYLLIUM

A new metal alloy of copper, nickel, silicon and aluminum has been found that promises to do the job of a strategic copper-beryllium alloy in accounting and billing machines, aircraft instruments and electrical instruments, the American Society for Metals was told at Los Angeles.

The copper-base alloy has good qualities of electrical conductivity, corrosion resistance and springiness. Developed at Battelle Memorial Institute, Columbus, Ohio, for the International Business Machines Corporation, the metal also promises to be "somewhat less" expensive than its copper-beryllium forerunner.

Although the copper-beryllium alloy is a little better, beryllium is critical because of its possible large-scale use in the atomic energy program. It also is expensive, selling for about $71 a pound, as contrasted to the less-than-a-dollar selling prices per pound for each of the new alloying elements.

PROJECT SOLAR SYSTEM

BYRON DEWITT
Glencoe Public Schools, Glencoe, Illinois

At one time the study of Astronomy was considered relatively unimportant. With the exception of a few men of science, the study of the heavens was far too remote when compared to the more earthly issues of men. The words *astrology* and *astronomy* are often believed to be synonymous. We no longer believe that man's fate or the course of human events is influenced by the movements of the stars and planets as in astrology. Astronomy as the science of the nature and movements of stars, planets, and other heavenly bodies is not only one of the most fascinating of all sciences but today it is supplying more and more of the answers that man seeks.

Man is a curious and creative creature. Combine this with an insatiable quest for more than his immediate fund of knowledge and progress results. Throughout the ages each generation has been the recipient of the progress made by the preceding generation. The evidence of such progress is not readily absorbed by immature minds. The comprehension of knowledge must parallel maturity.

In early introductions to astronomy the child soon learns that the place in which he lives is only a small part of a great solar system. It is a natural urge for him to become interested in the stars, planets, and other heavenly bodies. We as teachers are not only able to provide astronomical information and data accumulated by years of painstaking and careful research by astronomers, but we can make use of one of the greatest aids to first hand experiences—the sky itself. Too often this vital and realistic source of information is neglected.

There is no doubt that one of the focal points of interest in any elementary science program is the solar system. Today more than ever before there is a desire on the part of the child to know about this amazing system. The child's vivid imagination quickly pounces upon the very thought of other planets whirling through space at great speeds. Any science teacher knows of the many queries about the size, shape, and position of the planets in our solar system.

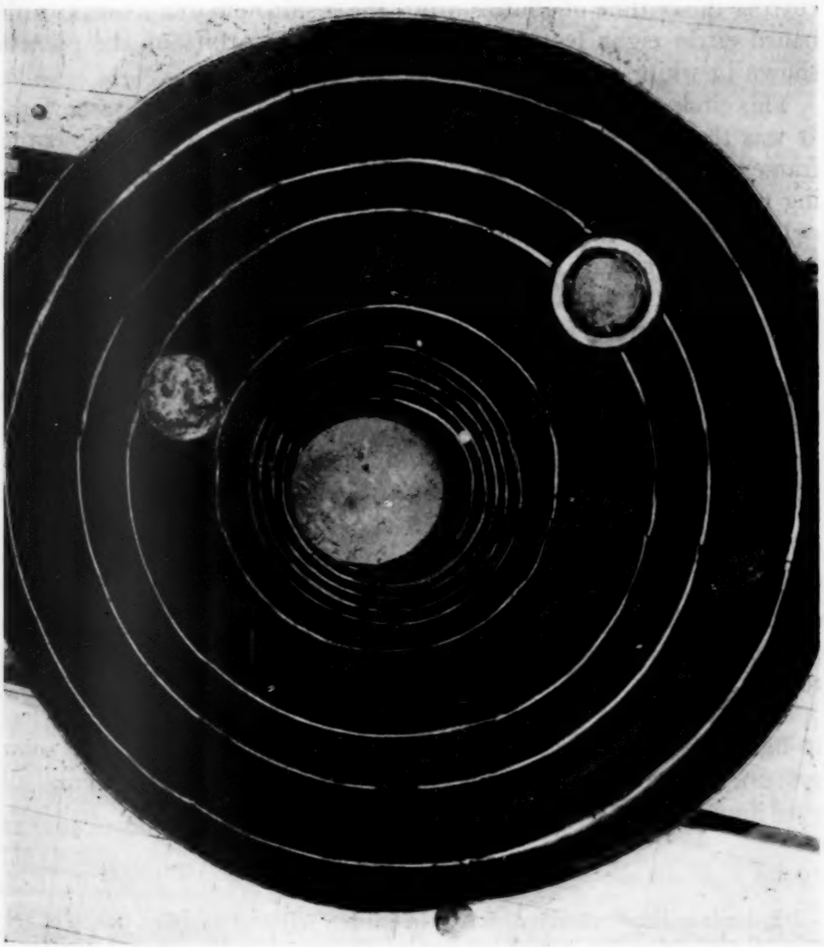
In this phase of the science curriculum many teachers may have sensed that something was lacking in their approach. Perhaps many may have felt that in some way the group enthusiasm which was so apparent at the beginning of the unit has dwindled. Here is how one elementary science class helped make their unit more meaningful.

Early in our study of the solar system we came to a group decision. We needed something more than isolated pictures of the planets

Scale
1000 miles = $\frac{1}{8}$ inch

	Diameter (Inches)	*Distance from Sun (Inches)*
Sun	14 in.	
Mercury	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.
Venus	1 in.	$\frac{5}{8}$ in.
Earth	1 in.	between $\frac{7}{8}$ in. and 1 in.
Mars	$\frac{1}{2}$ in.	$1\frac{3}{8}$ in.
Jupiter	11 in.	$4\frac{3}{4}$ in.
Saturn	9 in.	$8\frac{7}{8}$ in.
Uranus	4 in.	$17\frac{3}{4}$ in.
Neptune	4 in.	28 in.
Pluto	$\frac{3}{4}$ in.	$36\frac{1}{2}$ in.

Scale:
1 inch = 100,000,000 miles



which did not usually depict relationships as to the size of each planet, or the distance of each from the sun. Something more dramatic in a visual sense was needed—something which at a glance would show each child the size of the planets in relation to each other, their position and appearance, and their respective orbits.

After exploring many possibilities, the group agreed that a model of the solar system constructed as closely to scale as possible was the answer. The ceiling of our room was selected as the place for the finished model, and the project was on.

An eight foot orbit was decided upon for Pluto. Using data which had been checked for accuracy by the Yerkes Observatory, the class calculated the orbit of each planet. These orbits were then plotted on a piece of carboard eight feet square. White chalk on a black background made the orbits stand out very effectively. After cutting the outline of Pluto's orbit, the result now was a black cardboard circle eight feet in diameter with the orbits of the planets shown in white.

This circle was made rigid by securing it to a light wood framework. It was then mounted on two twelve foot strips of wood. The entire framework was lifted to the ceiling with the long pieces of wood resting firmly on the indirect lighting system.

Using a one-inch diameter for the earth as a scale reference we determined the size of the other planets. We realized that due to the great size of the sun in comparison to the other planets it would be impossible to show the true size of the sun on our model, and we simply made it considerably larger than the other planets.

Using the scale 1 inch equals 100,000,000 miles, we computed the relative distances of the planets from the sun:—Mercury, $\frac{3}{8}$ inch; Venus, $\frac{5}{8}$ inch; Earth, between $\frac{7}{8}$ and 1 inch; Mars, $1\frac{3}{8}$ inches; Jupiter, $4\frac{3}{4}$ inches; Saturn, $8\frac{7}{8}$ inches; Uranus, $17\frac{3}{4}$ inches; Neptune, 28 inches; Pluto, $36\frac{1}{2}$ inches.

The planets were constructed from various materials such as papier mache, wood, sponge rubber, and rubber balls. A large rubber outdoor ball painted orange was used for the sun. Each planet was painted and, after having "passed inspection," was attached to its respective orbit by piano wire.

This project was a wonderful experience for our class, and we feel it has helped us immeasurably in our understanding of the solar system. When we mention the word "planets" or "solar system," all eyes immediately focus on our ceiling.

"Soil mineralizer" slowly dissolves in garden soil and supplies traces of the mineral elements often lacking but needed by vegetables for vigorous growth.

THE CASE AGAINST HIGH SCHOOL PHYSICS

Paul DeH. Hurd
Stanford University, Stanford, Calif.

One of the most incongruous situations in secondary school science is to be found in the teaching of high school physics. As a science physics has played an important and dynamic part in the development of our "scientific age" yet it is the most likely subject to be eliminated from the high school curriculum within the next decade as a separate science. The influence of physics has grown in the world of science for the past 50 years yet the per cent of students in high school physics classes has dropped consistently. Adults wish they had had more physics; students in high school are averse to taking the course. Teachers of physics are the most agreed of any group of science teachers as to what content should be included in their courses; educators are just as agreed that it is one of the curriculum areas needing the greatest change in content.

A purpose of this article is to trace the educational thinking that has led to practically the extinction of high school physics while simultaneously generating a newer type of science course. For the educator the article illustrates what a half century of writing, discussion, committee reports, and research upon a single course can achieve in terms of curricular change.

On the basis of available national figures the per cent of high school students enrolled in physics at selected periods since 1895 has been as follows.[1]

1895—22.77
1905—15.66
1915—14.23
1928—6.85
1940—5.60[2]
1947—5.49

The 1947 survey showed the physics enrollment varied from state to state with a low of 1.4 per cent to a high of 8.8 per cent of the total high school enrollment. Considering only the students enrolled in the eleventh and twelfth grades the enrollment in physics represents about 13.3 per cent of this number. Compared with the other commonly offered secondary school sciences, physics ranks lowest in the per cent or numbers of students enrolled.[3]

---

[1] Johnson, Philip O., "The Teaching of Science in Public High Schools," Bulletin 1950, No. 9, Federal Security Agency, Washington, D. C., p. 6. (All percentages except 1940.)

[2] Hunter, George W. and Spore, LeRoy, "Science Sequences and Enrollment in Secondary Schools of the United States." *Science Education*, 26, p. 75, February, 1930.

[3] Johnson, *op. cit.*, p. 8.

The physics situation is even more alarming when considered from the point of view of the number of high schools now teaching physics. A recent survey of 625 high schools representing all sections of the country showed that only 298 or 47.8 per cent offer courses in physics.[4] This figure is a smaller per cent than that for any of the four major science courses taught in high school. Maneval recently surveyed the status of physics teaching in Oklahoma high schools and found that of 51 high schools teaching physics in 1922 only 13 were still teaching physics in 1951. In the schools offering physics the physics enrollment had dropped from 8.3 per cent to 4.5 per cent.[5] While the size of the high schools has some effect on the number of science courses offered, "physics, in contrast to chemistry, is offered in many of the smaller high schools."[6]

Science teachers have not been unaware of the enrollment problem in physics and much has been written to suggest improving the situation. The writer, in order to ascertain the major factors and course of events that have led to the decline of physics, made a sequential analysis of pertinent committee reports on physics teaching for the last half century. The cooperative thinking of thousands of science teachers upon the problem is reflected in the statements and recommendations of these committees.

As early as 1894 the "Committee of Ten" suggested that science teaching should prepare students for the "duties" of life. "The secondary schools of the United States taken as a whole do not exist for the purpose of preparing boys and girls for college."[7] The committee added however, "that there should be no difference in the treatment of physics, chemistry, and astronomy for those going to college or scientific schools and those going to neither."[8] In numerous instances the same assumption is found operative in the teaching of high school physics courses even today.

In 1906 a committee, with C. R. Mann as chairman, was appointed by the Central Association of Science and Mathematics Teachers to investigate difficulties in the teaching of physics. The need for an investigation of this type had developed from a concern over the decreasing enrollment in physics and a dissatisfaction with achievements in laboratory work. Many suggestions for the improvement of physics teaching were made by the committee, among which were:[9]

---

[4] *Ibid.*, p. 5.

[5] Maneval, Max V., "The Status of Physics in Oklahoma High Schools of 1951," *Science Education*, 35, p. 241, December, 1951.

[6] Johnson, *op. cit.*, p. 18.

[7] *Report of the Committee of Ten on Secondary School Studies*, Published for the National Education Association by the American Book Co. (New York, 1894), p. 51.

[8] *Ibid.*, p. 118.

[9] Mann, C. R., Chairman, "A New Movement Among Physics Teachers," *School Review*, 14, pp. 212–216, 429–437, 652–659, 746–753, March, June, November, December, 1906; 15, p. 290, April 1907.

1. The aims of physics were considered to be that of bringing the student into intelligent touch with the world of natural phenomena about him; to develop certain "powers" such as, reasoning, observation, interpretation, accuracy of measurement, solving problems and the scientific method of thought.

2. The committee felt the best results could be achieved by teaching a minimum number of "fundamental principles" with wide application. These principles were then to be organized around a larger unifying principle, that of energy. The concepts developed were to be chosen from the everyday experiences of the student.

3. Laboratory experiments would be selected primarily upon the basis that the experiments illustrated an important principle of physics; were interesting to the student and demonstrated the methods of the scientific worker. It was recommended that less emphasis be placed on quantitative experiments, although the importance of some quantitative work was recognized.

4. In reference to the student it was stated "he must be able to apply these principles to the solution of simple, practical concrete problems."[10]

5. In regard to testing, the committee stated that "tests should be frames to test the student's understanding of an ability to use general principles."[11]

It is difficult to realize why the report of this group of physics teachers, made almost a half century ago should have had so little influence in bringing about any fundamental changes in the teaching of physics.

Again, in 1910 the Central Association of Science and Mathematics Teachers appointed a committee, this time to study the fundamental purposes of science teaching in high schools. The committee stressed the point that science courses should ***not*** be looked upon as fitting students for college, "but as a means of introducing to new fields of human interest and appreciations; as furnishing tools for solving problems; as creating general intelligence for life activities; and as giving a valuable method of thinking and of getting true conclusions."[12] To aid in the full achievement of the above ends physics was felt to be of sufficient importance to recommend its requirement for all students.

The National Education Association Committee on the "Reorganization of Science in Secondary Schools," recommended a program of science teaching which would contribute directly to the

---

[10] *Ibid.*, p. 748.

[11] *Ibid.*, p. 748.

[12] Galloway, T. W., Chairman, "Report of the Committee on Fundamentals of the Central Association of Science and Mathematics Teachers," School Science and Mathematics, 10, p. 808, December, 1910.

Cardinal Principles of Education.[13] Physics in turn was described as a subject which should place emphasis upon the commonplace manifestations of science with stress on the home, farm, and industries.

A special committee of the Central Association of Science and Mathematics Teachers was appointed in 1920 to prepare an outline or syllabus for a course in physics from the point of view of life situations.[14] The work of the committee was to bring the teaching of physics more in step with developments in other science courses, i.e., more practical and less formal. The extensive work of the committee in the development and classification of physics topics taken from life situations seems to have had little influence upon the traditional practices in teaching physics.

In 1928, a committee appointed by the American Association for the Advancement of Science, was asked to define the general purposes of science in the secondary school curriculum.[15] The committee recommended that science courses in the high school and junior college should *not* be organized for vocational preparation or for the training of science specialists; this should be left to the senior college and university. The committee recommended the extension of a broader background type of course not only for secondary schools but also for the lower divisions of colleges and universities. The social function of science was recognized as an aim of science teaching which should receive greater emphasis.

A committee appointed by the North Central Association in 1929 made an extensive study of physics courses and reported as follows:

1. "A course in physics should add to the pupil's knowledge as much as is feasible about the physical world in which he lives so that he may use it in his everyday living, making him more efficient socially and vocationally.
2. The subject matter should bear largely upon the necessities and experiences of daily life."[16]

Possibly the most far reaching report on science teaching was made by a committee of the National Society for the Study of Education under the chairmanship of S. Ralph Powers. The committee's point of view was that "pupils in high school physics should develop *better understandings of*, and *abilities to use*, those fundamental concepts and major generalizations of physics that will enable them to better interpret natural phenomenon, common applications of physi-

[13] Caldwell, Otis W., Chairman, *Reorganization of Science in Secondary Schools*, Bulletin, No. 26 (1920), (Washington: Government Printing Office, 1920) p. 7.

[14] Vestal, C. L., Chairman, "Report of the Sub-Committee of the Central Association of Science and Mathematics Teachers (1920) on the Content of High School Physics," School Science and Mathematics, 31, pp. 274–279, March, 1921.

[15] Caldwell, Otis W., Chairman, "On the Place of Science in Education," School Science and Mathematics, 38, pp. 640–664, June, 1928.

[16] Hurd, A. W., "Reorganization in Physics," *The North Central Association Quarterly*, 4, p. 278, September 1929.

cal principles, and industrial applications of the principles of physics."[17] The committee suggested a course organized upon those generalizations of physics "that ramify most widely into human affairs and leads one to an increased ability to interpret the phenomena of their common experience." The report of this committee led to new editions of high school physics textbooks purportedly organized on a "unit" basis with stress on principles. The major divisions of the text were left undisturbed in practically all cases.

Science in General Education, a report of the Committee on the Function of Science in General Education of the Commission on Secondary School Curriculum, recommended a program of high school science based upon the many personal, social, and economic needs of adolescents.[18] The committee recommended the teaching of a type of science course based on *broad problems of living*. This science course would draw its data from all the fields of science without respect for subject-matter boundaries, either between the sciences or any other areas of the high school curriculum. The specific interests of individual students were recognized as the starting point in each unit of work.

A Committee appointed by the National Association for Research in Science Teaching reporting on high school science courses in general, recommended a modification from present practices to include materials of greater social significance.[19] And at the same time they suggested a need for constant integration not only with the other aspects of science education but with other phases of general education. The committee favored a teaching procedure based on problems which would duplicate as nearly as possible real life problems.

Several years later Vodenberg reported for the committee appointed to study "High School Physics for General Education."[20] The committee recommended fewer concepts of physics be taught and "then to place very strong emphasis on the use of these concepts in life situations; and to resort to mathematical symbolism and numerical results only when these devices give definite advantage."[21]

The American Council of Science Teachers made a significant report on science teaching in 1942.[22] They accepted the point of view

[17] Powers, S. Ralph, Chairman, *A Program for Teaching Science*, The Thirty-First Yearbook of the National Society for the Study of Education, Part I (Bloomington, Illinois: Public School Publishing Co., 1932) p. 250.

[18] Commission on Secondary School Curriculum, *Science in General Education*, A Report Prepared by the Science Committee (New York: Appleton-Century Co., 1938).

[19] Hunter, George W., Chairman, "Report of Committee on Secondary School Science of the National Association for Research in Science Teaching," *Science Education*, 22, pp. 223–233, October, 1938.

[20] Vordenberg, Kenneth E., "High School Physics for General Education, Report of the Committee on Physics Teaching, Central Association of Science and Mathematics Teachers." SCHOOL SCIENCE AND MATHEMATICS, 41, pp. 548–552, June 1941.

[21] *Ibid.*, p. 551.

[22] Neal, Nathan A., Chairman, *Science Teaching for Better Living—A Philosophy or Point of View*, Published by The American Council of Science Teachers, A Department of the National Education Association (Washington, D. C., 1942).

that science teaching was most functional when it was directed toward better contemporary living. The committee stressed the importance of teaching a type of science that (1) could be applied to the solution of personal and social problems; (2) was related to everyday living; (3) would ultimately lead to human betterment; (4) would develop increased respect and confidence in science.

Another committee appointed by the American Council of Science Teachers explored "needs as a basis for redirecting science teaching."[23] This committee stressed the values of building science courses around the personal-social needs of students as objectives. They also recommended that the work in science should not be classified by courses or subjects, but as outcomes of science teaching or common goals of general education.

The Harvard Committee reporting in 1945 recommended that virtually all science below the college level should be devoted to general education.[24] A specific recommendation was made for a high school course highly integrated which would serve as an introduction to science as a whole.

The committee responsible for the yearbook on "Science Education in American Schools," published in 1947, emphasized the importance of science in our present culture.[25] Objectives were formulated consistent with "desirable types of human behavior." The subject matter content deemed of greatest value was that which was socially significant in the broad areas of human experience and related to problems encountered in daily living. The committee felt "physics teaching at the high-school level should largely reject the preparatory function and stress the contributions of physics to the general education of American youth."[26]

The extent to which physics textbooks and courses directly reflect changes and developments in contemporary society is shown in a recent investigation by Farrell. In this study Farrell determined "the relationships between the secondary-school science curriculum and the cultural pattern in the United States."[27] He found that "general science content showed the greatest amount of relationship to cultural trends, biology content reflected the second greatest number of cultural trends, chemistry next, and physics the least number."[28]

[23] Croxton, W. C., Chairman, *Redirecting Science Teaching in the Light of Personal-Social Needs*, Published by The American Council of Science Teachers, A Department of the National Education Association (Washington, D. C., 1942).

[24] *Report of the Harvard Committee*, "General Education in a Free Society," (Cambridge, Massachusetts, Harvard University Press, 1945).

[25] *Science Education in American Schools*, Forty-sixth Yearbook of the National Society for the Study of Education, Part I (Chicago, Illinois: University of Chicago Press, 1947).

[26] *Ibid.*, p. 211.

[27] Farrell, James V., "The Science Curriculum and the Contemporary Culture Pattern," *The Bulletin of the National Association of Secondary-School Principals*, 36, pp. 106–114, January, 1952.

[28] *Ibid.*, p. 113.

The series of references cited represent a majority of the major committee reports related in whole or part to the teaching of physics published within the last half century. Any synthesis of these reports would seem to suggest a type of physics course based on broad principles or problems, with highly integrated content; a course closely related to daily living rather than specific preparation for college; a course concerned with social problems related to science as much as with the scientific problems and their methods of solution; a course based on the present personal-social needs of adolescents. Other values to be obtained would be the development of an appreciation of science, its methods, its attitudes in approach to problems, its significance in present day society, and its potentialities for improving modern living. The course would be thought of as essentially "science" rather than "physics."

The type of physics being taught in many high schools for 1952–53 has slight resemblance to the type of course suggested by the various committees. Physics courses and their organization are about the same now as fifty years ago. The volume of content is greater for each topic, but the five major divisions of the course remain the same. The most notable innovation is a sixth section to many physics books, variously called, but all implying something described as "modern physics." This section is usually found at the end of the textbook. The "standard content" of high school physics is being and has been rejected by students and curriculum advisers for decades. Yet it persists, where physics is still offered.

A number of attempts have been made to alleviate the problem of physics teaching through other channels than a basic reorganization in point of view and content. These changes have been admirable and were recognizedly needed, but were not pertinent to the major issues.

A recent study on experiments found in high school physics laboratory manuals published since 1930 as compared to a group published before 1930 is typical of the situation in physics.[29] The author reported that "between the over-age group and the more recent 1930–1950 group there is such a high correlation of titles, that if the tabulation sheets did not identify to which series they belonged, they might be thought to belong to either group."[30] Most of the recent changes in the manuals were found to be in the format, substitution of line drawings, inclusion of graph paper and blank pages for drawings, modifications and rearrangement of the order of experiments. The greatest change between old and new manuals was the deletion

[29] Mack, Joseph A., "The High School Physics Laboratory Manual," SCHOOL SCIENCE AND MATHEMATICS, 52 pp. 562–572 and pp. 641–648, October and November 1952.

[30] *Ibid.*, p. 645.

of additional numerical problems appended to the experiment which did not directly grow out of the student's work.

Some teachers have felt that if physics textbooks were easier to read physics teaching problems would be solved. A recent study of this problem revealed that "as compared with textbooks for elementary science, junior-high science and high-school biology, the textbooks for physics are not likely to be as difficult for the grade level of student for whom they are designed."[31] The enrollment in physics has not been increased by making the texts easier to read.

Hunter and Spore sampled 655 secondary schools throughout the United States and tabulated the commonly used teaching procedures in each type of high school science course.[32] If the amount of individual attention given students is one example of good teaching, physics teachers make the best showing compared with other high school science teachers. Physics instructors also gave more individual laboratory experiments and used fewer references and reports than other science teachers.

It would seem from the total report that the teacher of physics uses very acceptable teaching techniques with students in an effort to have them achieve the contents of a single textbook and workbook. Johnson's survey for the U. S. Office of Education showed the average size physics class to be the smallest of any science taught in the secondary school, an average of only 19 students.[33] In spite of these apparent instructional advantages students have not found physics courses attractive.

Many teachers have felt that there is a need in the high school for a "strong," "rigorous," "college preparatory" course in science and that physics best meets this situation—that if students go on to college they must have a "good" high school course in physics or they are doomed to unsatisfactory achievement in college physics. Several rather extensive studies have been made on this particular point. Adams found that "the mean year mark in college physics for students having high school physics was 4.856; for those without high school physics, the mean was 4.758." He concludes "there was little or no difference in college physics achievement between those who had a year of high-school physics and those who did not have it."[34]

Foster found "the influence of high school physics on success in

---

[31] Mallinson, G. G., Strum, H. E., Mallinson, L. M., "The Reading Difficulty of Textbooks for High-School Physics," *Science Education*, 36, p. 23, February 1952.

[32] Hunter, George W., and Spore, LeRoy, "The Objectives of Science in the Secondary Schools of the United States," School Science and Mathematics, 43, pp. 633–647, October 1943.

[33] Johnson, *op. cit.*, p. 27.

[34] Adams, Sam, "A Study of Various Factors Related to Success in College Physics," *Science Education*, 36, p. 250, October 1952.

college physics seems to be high but . . . the influence of native intelligence seems to be still higher."[35]

Earlier Hurd had found that college students who had taken high school physics show a tendency to receive higher grades in certain units of college physics, "but they are not markedly superior to those not having had the high school course."[36]

The majority of studies are in agreement that students with a high intelligence, who like science, and who show a past record of good grades in the majority of their high school subjects typically do well in college physics. There is no real evidence that high school physics is essential to successful work in college physics.

If evidence existed to the contrary, modern trends in professional scientific preparation would belie the situation. In almost every major field of academic preparation today, science as well as non-science, the emphasis is upon a broad general background of preparation. Not only is this a recommendation for high school, but even through the first two years of college and in many cases throughout the entire undergraduate years. In fields of science the fertility of hypothesis is potentially increased by breadth of training, not by early specialization.

What is the answer to the problem of physics teaching? The one apparent answer is that physics is slowly being eliminated from the high school curriculum and a type of science course more in line with modern educational points of view is taking its place. The most recent Biennial Survey of Education[37] and other references show by title the following types of primarily physical science courses above the ninth grade which are replacing the traditional physics in the high school curriculum.

1. Generalized Science
2. Consumer Science
3. Senior Science
4. Applied Science
5. Basic Science
6. Practical Science
7. Industrial Science
8. Girls Science
9. Popular Science
10. Modern Science
11. Physical Science
12. World Science
13. Advanced Physical Science
14. Applied Physics
15. Advanced General Science
16. General Physics
17. Descriptive Physics
18. Advanced Science
19. Vocational Science

In addition to these titles there are several of more specialized non-

[35] Foster, C. A., "The Correlation of the Marks in Certain High School Subjects with Those in College Physics and College Chemistry," SCHOOL SCIENCE AND MATHEMATICS, 38, pp. 743–746, October, 1938.

[36] Hurd, Archer Willis, *Problems of Science Teaching at the College Level* (Minneapolis: The University of Minnesota Press, 1929).

[37] *Biennial Survey of Education in the United States* 1948–50, "Offerings and Enrollments in High-School Subjects" Chapter 5, pp. 111–112.

trade science courses such as:

1. Fundamentals of Electricity
2. Electronics
3. Radio
4. Aviation Physics
5. Preflight Physics
6. Aeronautics

No definite pattern or exact content of this type of course has yet emerged, but of those examined the majority of the science principles were drawn from physics, many from chemistry plus a smaller number from geology, astronomy, and meteorology. In terms of purposes they were all courses designed primarily to relate the principles of the physical sciences to everyday living, to increase interest in the physical sciences, to integrate the physical sciences, and to develop an appreciation of the methods and achievements of the physical sciences. Experiments in the courses were performed with less specialized and less classical equipment. Considerably less emphasis was placed on quantitative measurement. These courses are attracting many students who otherwise would have had an education sterile of physical science concepts.

These types of physical science courses are not new. Watson in 1940 determined that "courses in physical science of a survey nature and on all levels above the ninth grade were found in 28.5 per cent of all California High Schools. Such courses were found to be offered in at least one high school in 21.6 per cent of the cities in the United States that have over 25,000 population."[38]

These courses have been accused of being "not science," "fringe science," "non-academic," "vocational," "superficial," etc.; however, high school physical science is gaining in status. Carleton questioned 95 institutions of higher education of various types and distributed throughout the United States as to their acceptance of an outlined course in physical science which he submitted. Of the 78 institutions which replied "*every one of the 78 replicants gave approval, to some degree, to the proposal submitted to them;* that is, at least the 78 colleges replying to the query will give entrance credit for the course in Physical Science. A small number of these colleges stated that credit would be given but 'with certain reservations,' such as, laboratory work required; not as a laboratory science and in combination with another science."[39]

Various types of physical science courses, for the general student, to replace requirements of physics or chemistry have been developing in the colleges of the United States for the past twenty years. In 1949 a survey of 720 colleges revealed that 59 per cent had organized

---

[38] Watson, Donald R., "A Comparison of the Growth of Survey Courses in Physical Science in High Schools and in Colleges," *Science Education*, 24, p. 20, January 1940.

[39] Carleton, Robert H., "The Acceptability of Physical Science as a College Entrance Unit," *Science Education*, 30, pp. 127–132, April, 1942.

some type of general education science courses. A total of 344 colleges had courses in physical sciences and 81 additional schools gave a course combining both physical and biological sciences.[40] It appears colleges and universities have been quicker to recognize the inadequacies of specialized science at the freshman level than high schools have in regard to similar courses at the eleventh or twelfth grade level.

A review of the data seems to indicate that physics with its traditional objectives, organization and content has lost its place as a high school subject. It does not fit into either the high school or the college pattern of modern education. Over fifty years of continuous emphasis upon the need to make high school physics more functional in terms of the everyday life of the learner has been largely ignored by those responsible for elementary physics courses. The educational thinking which foreshadowed the decline of physics has at the same time defined the science course to replace it. Although the content of this new course is somewhat vague, its point of view and objectives are clear.

[40] Bullington, Robert A., "A Study of Science for General Education at the College Level," *Science Education*, 33, pp. 235–241, April, 1949.

MATHEMATICS ON THE MARCH

An institute for mathematics teachers will be held at the University of Michigan, Ann Arbor, Michigan, August 3–14, 1953. Excellent lecturers are on program, including:

Harlan Arthur, Ford Motor Company
John W. Carr, III, Willow Run Research Laboratory
Walter Carnahan, Purdue University
Harry C. Carver, University of Michigan and Consultant, U. S. Air Force
Clyde Coombs, University of Michigan, Psychology Department
Robert Elias, Western Michigan College of Education
Harold P. Faucett, Ohio State University
Arvid Jacobson, Wayne University
Phillip S. Jones, University of Michigan
Richard J. Wilson, Argus Cameras, Inc.
Arthur Bender, Jr., General Motors Corporation, Anderson, Ind.

Many interesting and instructive field trips are being planned. Study, discussion, and laboratory groups include Teaching Aids Laboratory, Field Work and Instruments, Mathematical Applications and Instruments, Arithmetic and General Mathematics in the Junior High School, Techniques and Materials for Vitalizing the Teaching of Algebra, Techniques and Materials for Vitalizing the Teaching of Geometry. For further information write to Phillip S. Jones, Mathematics Department, Angell Hall, University of Michigan, Ann Arbor, Michigan.

Chemical soldering iron needs no electricity because it works on "heat cartridges." Inserted in the iron, the cartridge is triggered by a firing rod that is pulled out and allowed to snap back. The iron heats in 10 seconds to about 800 degrees Fahrenheit, maintaining the soldering temperature for six to eight minutes.

THE SCIENCE JANUS

William Gould Vinal, "Cap'n Bill"
Emeritus Professor Nature Education, University of Massachusetts, Boston, Mass.

(*Concluded from May*)

Ernest Thompson Seton, The Artist

My first contact with Seton was at a camp fire at a YMCA camp near Ossining-on-the-Hudson. Philip D. Fagans, Executive Secretary of the Woodcraft League of America (1915) was director of a camp leader's training course. We marched silently and in single file to the camp fire circle. The setting was perfect. The leaders seated in a circle, elbow to elbow, the glow of the fire, the fragrance of woodsmoke, and the surrounding darkness. The great "Chief" arrived. I will never forget his tall, long dark-haired, magnetic personality. In orderly fashion there were woodcraft games, Zuni songs, nature observations, and the master story teller. His mimicry of wild animal voices reverberated in the deep silence of the forest. The Omaha Tribal prayer and the silent departure. What he did, what he said, the way he said it, penetrated deep into my nature. These repeated occasions are a long cherished memory.

Then there was the time that I visited his home at Greenwich, Connecticut. One hundred and fifty acres of forest and stream had been set aside as a wildlife and conservation experiment. What I recall clearest was a steam dredger at work excavating a lake and creating islands. It was a fifty dollar a day proposition. Seton the imitator, imitated the noises. He explained the 10 foot high, mesh wire-fence to keep out dogs and boys. The boys declared a war. In desperation he visited school and invited all twelve-year olds and upward to camp for the week-end. He expected 18; but 42 came. He furnished boats, tepees, and food. They were given liberty to holler, to take off their clothes, to swim, to sleep out. To date these things had been more or less verboten. When their animal spirits had had time to work, when they had eaten with woodsmoke for sauce, Seton spun one of his inimitable yarns. He next set the stage for election and self-government. Proceedings combined the idea of Robin Hood and Leatherstocking. Undoubtedly this was a typical woodcraft league campfire.

In 1930, Seton sold his Connecticut holdings and purchased 2500 acres near Santa Fe, New Mexico. One of the greatest honors extended to the writer was an invitation to serve on the staff of his Indian Lore School. Having just organized the Nature Guide School of Western Reserve University (1928) with a staff of fifteen plus an

attendance of sixty teachers and thirty-two children, to train for outdoor leadership, did not seem exactly the time "to desert the ship."

Seton, the twelfth of fourteen children, was born in England (1860). of Scot ancestry. He moved to backwoods Canada (1866), lived in a pioneer shanty, and attended a log school house. He craved knowledge but there were no books. When he heard the first bluebird, he cried, but never knew why. He did not dream that the making of hickory axe handles, blue beech sliver brooms, or basswood whistles had anything to do with education. They were a part of his life.

The family next moved to Toronto (1870). He was nicknamed "Squinty." Daily fights taught him self-reliance. The wild still lingered in his mind. At eleven he satisfied the creative urge by carving woodcuts of birds and beasts, making ink from soot, and getting out six copies of a paper on grocer's paper. Today these "hungers" are given satisfaction in schools, camps, and youth organizations.

In 1873, Seton saw the *Birds of Canada* by A. M. Ross in a bookstore window for $1.00. It took long hard work to earn the money. The book left much to be desired by way of scientific information. As a result the margins and spaces became filled with corrections and additions. Obstacles proved to be a challenge.

Seton's longing for the wild continued. Most of all he longed to be a naturalist but that was taboo because it did not offer a "living." His father wanted him to be an artist. He built a cabin (1874) secretly and imagined that he was Robinson Crusoe. He was so anxious to be like the Indians, he wore only shoes to get a tan.

He next had a chance to return to the old farm (1875). This gave him opportunity to satisfy his longing for companionship. He led boys in the ways of Indian life. Such personal experiences made possible *Two Little Savages* (1903). It was evident that Seton was a writer. His first writing was a poem to the "Kingbird" (1879). Whenever he wrote it was usually a case of wild-animal worship.

Another potential skill was that of the artist. In 1876 he found, and painted a portrait of a sharpshin hawk. At the age of 19, hungry and poorly dressed, he landed in London where he was one of six to receive a scholarship at the Royal Academy School of Painting and Sculpture. He had thought that all naturalists were dead but discovered the free library of the British Museum. Elliot Coues' *Key to the Birds of America* and Jordan's *Manual of Vertebrates* were the first authentic books to help him. They inspired him to collect. It has been said that every great ornithologist, in the early days, started off by stealing bird's eggs. Three of the "heroes of science" that I have chosen started off with the gun. Seton shot birds for knowledge but not to kill. Every species was measured and its food

and characteristics recorded in a "fat journal." He once said that "science is measurement." He also made sketches. In Comstock's *Handbook of Nature-study* there is a page "from the field notebook of a boy of fourteen who read Thoreau and admired the books of Ernest Thompson Seton." The writer recalls that it was very early in his career that he abandoned the autocratic style of the lab technician and adopted the Thoreau-Seton method for teacher-training.

Seton had to fight his own way. He was self-educated. Of course, as a principle of education, every one is self-educated. Whenever Seton needed money, which was often, he turned to painting and writing about wildlife. For the painting of common birds in Toronto he received $60.00. When he was broke in New York City he became an artist days and in the evenings wrote animal stories for St. Nicholas magazine (1883). Perhaps this was his apprenticeship.

Seton was always a free lance. I suspect that today he would be one of the first to champion academic freedom. He was alternately lured to the wilds and to the big city, usually Paris or New York. In the city he met the artist-naturalist Dan Beard, did drawings for C. Hart Merriam, and helped illustrate Chapman's *Handbook to the Birds of America*. Every time he returned to Canada he found that the prairie openings were disappearing. The *Trail of the Sandhill Stag* was the hunting and killing of a moose. At that time he vowed that he would never again kill big game. His life as a cow puncher led to *Lobo King of Currumpaw* (1894). Seton's sympathy was with the big, bad, gray wolf of the woods and not with the conquest of the plow. His *Wild Animals I have Known* (1898) were not like humans as in Kipling but were stories based on facts. Mammalogists have always recognized Seton as an authority.

However, Seton wrote at a time when sentimentalists were rampant. When John Burroughs attacked William J. Long (Atlantic Monthly, March 1904) as a nature fakir, he included Seton. This was because he did not know Seton. Burroughs later wrote an apology (Atlantic Monthly, July, 1904). and recognized him as the "greatest raconteur." Seton also received the John Burrough Gold Medal.

Scientists recognize Seton's monumental work. His *Lives of Game Animals* (4 volumes) are records of facts with vivid, realistic drawings. The governments of Manitoba, Smithsonian, and the U.S. Biological Survey employed him as a naturalist. He received the Elliott Gold Medal of the National Institute of Sciences. Perhaps the greatest tribute was from the public who accepted him as a popular lecturer, not only in the United States, but in England, France, and Germany.

It should also be added that Baden-Powell credited Seton and Dan

Beard with being fathers of Boy Scounting. The "Seton Indians" were organized in 1902 and Beard's "Sons of Daniel Boone" in 1905. For five years Seton was the "Chief Scout." The Birch Bark Roll of Woodcraft (1902) was an outgrowth of *Two Little Savages*. As a final analysis it is well to remember that scouting is still growing and is the result of many minds.

Ernest Thompson Seton was a generalist, a naturalist, an artist, a writer, and a leader of youth. He wrote: "Because I have known the torment of thirst, I would dig a well where others may drink." Through it all he was guided by interest, talent, common sense, nature, and the code of Robin Hood. May the nature guides of today's youth profit by his example.

Hermon Carey Bumpus, Educator (1862–1943)

Many a present-day student would be fortunate to have been born much earlier in order to have his interests developed in defiance of specialization. Hermon Carey Bumpus came into a favorable environment for the nurturing of his talents and interests. As a boy he was more interested in snakes and insects than in transitive and intransitive verbs. He earned his first money by dehydrating a skunk. He arrived at Brown University (1879) at a time to benefit from three great generalists who considered nature a thing of beauty and joy, as well as knowledge. Bumpus' college days were filled with leaders so rich in life's values that it deserves to be told in a volume by itself. John Whipple Jenks (Professor in 1871) camped for 50 days in the Florida Everglades (1874). He collected "Turtle Eggs for Agassiz." Dallas Lore Sharp, another Brown man, made the latter event a literary classic in the Fiftieth Anniversary Number of the Atlantic Monthly. There was Alpheus Spring Packard, pupil of Agassiz, and Professor of Zoology and Geology (1878), who wrote about glaciers, embryology, and insects. Packard taught at Agassiz's School of Natural History at Penikese (1873) and helped establish the summer school of biology at Salem (1875–1878). He was not above lecturing to the weavers in the mills at Valley Falls. Then there was William Whitman Bailey (Professor in 1881), a student of Gray, who was a chemist, zoologist, botanist, geologist, poet, editor, and alpinist. He wrote for the Providence Journal for nearly fifty years. The mantle of three great naturalists fell upon Bumpus who proved himself worthy.

Bumpus, like Stefansson and Seton, was a biological renegade. He had little use for formalism. He would have taken great delight in the recent newspaper announcement that Brown University has performed an appendectomy on the one-text method. He would have viewed as progress the diminishing of fruitless lectures. I recall the

merry twinkle in his eyes when he told me that Sharp was not interested in marks or faculty meetings. In "straight-jacket" days, when the Lab-mold was turning out the same pattern of student, it was always refreshing to talk with Bumpus.

Bumpus was never "discounted" for his non-conformism. When Professor Packard was on leave of absence (1884–1885) Bumpus was invited to substitute. When President Andrews called him to Brown (1890) he paid this compliment: "He is not . . . a narrow specialist but thoroughly informed in every branch of the science of life." A long series of degrees testify to his scholarship. PhB Brown (1884); PhD Clark (1891); ScD Tufts and Brown (1905); LLD Clark (1909). He was elected to Phi Beta Kappa (1891) and to Sigma Xi (1900). His ability to specialize in one field was demonstrated in his PhD dissertation on "The Embryology of the Crustacea," in which emphasis was on the American Lobster.

Bumpus was elected Professor of Comparative Anatomy at Brown (1892–1901). As was to be expected, he soon upset the plan of orthodox teaching. His contagious enthusiasm led sixty students to spend a blustery March vacation on an oyster dredger in Narragansett Bay. The innovation was not exactly "vaudeville" but did show the lack of aloofness and a marked interest. His first graduate student was Dr. Albert D. Mead, an artist-naturalist and man of the community. Mead was not only big enough to head the biology department but later became vice-president of the university. Dr. Herbert Eugene Walter was another student-admirer and generalist who became a member of the biology faculty.

At no time, in the author's experience, did Brown professors have to be divested of the attitude of superiority so commonly held by the guild of specialists. It is not surprising, then, that Bumpus, the cosmopolitan had broad community interests. His list of public offices is a tribute to the general confidence in his scientific knowledge and capabilities. In the early nineties he held extension classes to prepare *teachers* for science in the elementary grades. He convinced fellow *sportsmen*, as member of the R.I. Fisheries Commission (1897–1901), that starfish and crustaceans were legally inland fish; he was a member of Board of Trustees R.I. *Hospital* (1895–1901); on Board of Management of R.I. School of *Design* (1899–1901). He helped to organize, and was first president, of the *Audubon Society* of R.I. He was one of the sponsors of the Boston Children's *Museum* (1912). In all of these varied positions his inner spirit was that of open-mindedness, fearlessness of expression, and a high standard of honesty.

Clark University was founded in 1888. Dr. G. Stanley Hall was president (1888–1920) when Bumpus received his PhD in 1891. At

Williams College (1867) Hall had given his probable profession as the ministry. His trial sermon was so heterodox that the president of Union Theological Seminary instead of offering the usual criticism, offered a prayer in his behalf. Hall "soaked up" the ideas of Darwin, Spencer, and Huxley. Hall as a boy collected stones, leaves, and bugs and when he became a man his hobby was farm tools and antique furniture. Bumpus at Clark found continuing sympathetic help and enriching influences.

The Marine Biological Laboratory at Wood's Hole was founded the same year as Clark University. Dr. Charles O. Whitman was made director (1889) and Bumpus Assistant Director (1893–1895), until he became Director of the U.S. Bureau of Fisheries. As a member of the Board of Trustees of the M.B.L. he suggested marine supplies to school labs to increase the funds.

Any biography of Bumpus is compelled to deal in decades. It took about ten years for his "revolutions" to reach the people. He would then proceed to the next "firing line" for distinguished service in nature education. If we consider his decade of teaching at Brown as 1890 to 1910, the next ten years was as the first director of the American Museum of Natural History. Here again he could not be accused of either being a traditionalist or a high brow. He immediately set forth to humanize it. He freed the "spirit specimens" for "realistic groups in an outdoor atmosphere," invited in school children for nature talks, sent traveling exhibits to schools, and set up an education department under George H. Sherwood. The Latinized book plates were changed "For the People; For Education; For Science." There were those who considered the placing of science last as scandalous. He knew that science is not gadgetry or black magic and proceeded according to his convictions. His contributions are now accepted as commonplace and his exhibits were the fore-runners of Audio-visual education. Characteristically, he formed the American Association of Museums (1906) and was its first president. He said that "The man who never learns is a dead teacher. The museum that is not actively and ambitiously contributing to science is a poor institution." As President Washington said in his farewell address, "In proportion as the structure of a government gives force to public opinions it should be enlightened."

The next decade found Bumpus as the University administrator. He was the first Business Manager of the University of Wisconsin (1911–1914) and then President of Tufts College (1914–1919). If a distinguished pedagogical tree was important, if scholarship was necessary, if a long list of degrees counted, if administrative experience was a precedent, if resourcefulness was to be used, if scientific procedure was a help in the analysis of problems, he was certainly

equipped. Each new position was an enlarged challenge. He was always heralded as one who would succeed. He made good use of the opportunity. And in due time he had set his house in order for the next event. He was ever characterized by sincerity, progressiveness, and of good judgment.

The educational world was always trying to catch up with Dr. Bumpus. His Directorship at the American Museum (1900–1910) was a training period for National Park Service (1931–1940). He gravitated to the chairmanship of the Committee on Outdoor Education for the American Association of Museums. He was immediately challenged with the fun of applying museum education to teach conservation out-of-doors. He was appointed chairman of the National Park Advisory Board (1931). This led to the Everglades National Park. As early as 1926 he had suggested that the trees on Boston Common have more than scientific labels. This idea still has to be accomplished. With $75,000 received from the Laura Spelman Rockefeller Memorial he was enabled to set up model park museums. The new Yosemite Museum was opened to the public in May, 1926. Exhibits included geology, biology, and ethnology. He saw the need of "interpreter houses" beyond the main area which he called "*Trailside Museums.*" He considered them as "a hook-up between an object, or spectacle, charged with dynamic information and a mind receptive to informational impulses." The Committee on Outdoor Education gave funds and spirit to experimental projects at Glacier Point, 3000 feet above Yosemite Valley (1925); the Bear Mountain Museum in in the Palisades-on-the-Hudson (1927); and Yavapai Point on the rim of the Grand Canyon (1928). Bumpus also conceived "natural history shrines" or exhibits in situ. One of these was a tree stump at Crater Lake that had been changed to charcoal during the eruption of Mount Mazama. For his National Park Service work, Bumpus was awarded the Cornelius Amory Pugsley Gold Medal for 1940. I believe that he might have considered his greatest honor, and his honors were legion, his recognized title as "The Father of National Park Trailside Museums."

My closest association with Doctor Bumpus was when he was a Duxbury neighbor, just two-towns away. We had time to hobnob at an outdoor meal or in front of the fireplace. There was much to talk about. His home was the King Caesar house over-looking Duxbury Bay. King Caesar, merchant-tycoon of a large fleet (1780–1840), built a mansion at Powder Point. This was now an art museum of early American furniture. The century-old barn was also a museum but not the hum-drum kind of a lab technician. I can still see his eyes twinkle when we added to his collection of apple parers. Bumpus thoroughly enjoyed showing his collections. It was with great satis-

faction that he guided us about the John Alden House. His interest in local history was the same enthusiasm that caused him to investigate the Aztec ruins in Yucatan in 1910. Rebuilding old houses was recreation. In Duxbury he really reached the abundance of life. Without his brain becoming rigid, or soft, he retired to the fine art of living. He had so many interests, he was what the psychologist calls a true "extrovert." In the words of Theodore Roosevelt, he was having "a perfectly corking time."

Bumpus exuded humor. To mention his name to an acquaintance brings forth anecdotes and chuckles. In our guest book at Vinehall I find on August 25, 1936:

Lucy Ella Nightingale Bumpus
H. C. Bumpus, her husband.

It was with a roguish look that he affixed his name. He related about students "whisking tooth picks through Packard's whiskers," until the dignified scholar looked like a porcupine. Bumpus did not claim to be one of the pranksters but in telling the yarn, he laughed until the tears ran down his face. Then there was the hot muggy Sunday when he was plastering one of his rehabilitated houses. The plaster and sweat was running down his bare arms. Suddenly a dressy woman loomed in the doorway. She asked many questions about old houses and antique furniture. Finally she rubbed her eyes and wanted to know his "profession." When he said "Plasterer" she replied: "You know too much about history to be a mason. Really, what is your profession?" He admitted being a college president. Later he heard her hollo to her husband: "Come on in; there is an old nut of a plasterer in here who thinks that he is a college president." Bumpus was chock full of whimsically apt stories.

Hermon Carey Bumpus' life was more than an individual span, it was a culture. The bonds of biology and humanism were never absent. His values were completely alien to the pickle-jar patterns that would-be biologists were being subjected to. He dared to be himself. His world was certainly different from mediaeval collecting for biological morgues, appending Latin epitaphs, taking notes, and verbatim regurgitation. The scientific importance of Stefansson's second expedition to the Arctic appealed to him. The need of pay-dirt in research in cancer and polio was evident. He knew that we also need scientists interested in collaborating in all fields of science.

Conclusions

After teaching Nature Education for nearly half a century one has earned the right to stand before the mirror and review his thoughts. One's viewpoint changes. Blind respect also changes. Perhaps con-

fession is good for the soul, such as the admission that attending the AAAS is not so much to endure highly specialized droning in a "foreign" language in a tenth floor "cubicle," as to visit with mutual friends in the lobby. Four type naturalists have been presented as humans whom I have enjoyed meeting in the corridors of life. The reader should not jump to the conclusion that I consider all other scientists as objects for the humorist (Some are); as marked men (Some are); as politically naive (Many are); or as bores (Many are). It is equally true that all college students seeking to major in generalized science are not gullible; many have integrity; and many cannot be muzzled. Just because I have seen a one-celled zoologist; feuding botanists; and isolationists of all kinds, is no criterion that all individuals or colleges are of that ilk. Each individual or group must be judged on merit. It can be agreed that the scientific method includes generalization from observed facts. If we further agree that checking the generalization may lead to a new generalization we have taken another step forward. This article has been an attempt to show that one may specialize in the field of generalization and with profit.

The history of biology includes artifacts, plants used, animals outwitted, diseases controlled, tools invented, art achieved, and language expressed. These things cut across the specialized sciences. Every prehistoric man, every agriculturist, every conservationist, every citizen, every scout, every camper, every migrant to the outdoors is a general naturalist. Food, clothing, shelter, weather, and creativeness are mysteries or pleasures. How we meet these affairs head-on, as individuals or as a group, is the "science of life" or biology. It has been seen that nature education is old. It is also new. It is a field for which there is a marked need and practical concern.

Methods in general natural history have changed. The idea of presenting *physiography* was once in order. The scarcity of teachers who could do it led to classes in *general science*. This was also too much for teachers. College courses called *orientation* are attempts to give freshmen a generalized perspective. So far it has been just "fragmentized" science. The *integrated* approach and the *core* program have only proven to be a parade of "vignettes." They presuppose that an educated man can contemplate the universe of science in ten easy painless lessons by "scripture measure." Personally, I am convinced that the enormity of the task has not been realized. We have had a tiger by the tail when we thought that it was a few grains of mustard seed. We cannot make it rain by any such beating of hollow drums. We cannot send a child to do a man's work. The four naturalists, and the "four persons" did not achieve short of a life time. This day and age is not any simpler.

The common denominator to be found in the lives of Comstock,

Stefansson, Seton, and Bumpus may be symbolic of what is needed. They saw the significance of the "wholeness" of natural history. They had good heredity and good personalities. They were individuals with a zest for living. They were country born into the vast dominion of natural resources. In their youth they roamed the countryside as adventurers. They often walked alone but they did have help. They were non-conformists. They were self-made. Their interests were not random or whimsical. They elected projects, hobbies, and challenges according to their opportunities, interests, and skills. They were always naturalists. They were not only biologists, but educators, writers, artists, photographers, travelers, conservationists, humanists. They were teachers but never dry-as-dust pedants. They were craftsmen but never doodlers. They did not fear the truth as they saw it. They enjoyed their work for its own sake. They found rewards rich in satisfaction but not in artificial grades. They were creative in art, handcraft, poetry, or music. They helped to solve practical problems. Not one of them failed the common people. They never sacrificed students. They aimed for richer, better lives for children. They made a large output, a continuous series of writings. They were alert to new ideas. They were tolerant. Their influence not only carried into the schools but into the homes and to adults. They had followers. Each was a man of letters, a genius in accomplishment, and in the harness to the end. Each left an imprint. They were prophets. They were sensitive to the aesthetic. They had something of the poet's imagination. They had a delightful sense of humor. If we refuse to train the future Comstocks, Stefanssons, Setons, and Bumpus we unwittingly may be abetting the Russians and communism. The chief justification of the generalist is the idea of the dignity and worth of all people.

Bibliography

The reader is referred to the following publications for an extended account of the four naturalists.

Anna Botsford Comstock, "The Lengthened Shadow of a Man and His Wife." By James G. Needham, *The Scientific Monthly.*

Vilhjalmur Stefansson, "My Life With the Eskimo." The Macmillan Company, Autobiography, Macmillan Company, due in 1953.
Harvard College, Class of 1906, Anniversary Reports.

Ernest Thompson Seton, "Trail of an Artist Naturalist." An Autobiography. Charles Scribner's Sons, New York. 1941.

"Hermon Carey Bumpus, Yankee Naturalist." By Hermon Carey Bumpus, Jr. The University of Minnesota Press, 1947.

"Nature Recreation in Various Cities." By William G. Vinal. A series of Articles in School Science and Mathematics, years 1935–1938.

"A Survey of Trailside Museums and Nature Trails." By Martha B. Coady. Thesis for degree of Master of Science, University of Massachusetts, 1950.

MAGNETISM

S. R. Williams
Amherst College, Amherst, Mass.

CHAPTER II

Artificial Magnets

Steel Magnets. By proper procedures a bar of steel may be made into a magnet, which we call an artificial magnet in contradistinction to a natural magnet, that is, one which in its natural state already possesses the properties of attraction and repulsion of other magnets and gives direction in a magnetic field. Natural magnets were described in the preceding chapter. Artificial magnets may be prepared from nickel and cobalt, but they are by no means so powerful as those made from steel. There are many alloys also from which artificial magnets may be made and which will be described more fully later on. Some of these alloys furnish much stronger magnets than does ordinary steel.

It is difficult to say by whom and when the transition from natural to artificial magnets was first accomplished. Gilbert in his book says, "Plato states that the magnet allures iron, and that it not only draws iron rings but also endues the rings with power to do the same as the stone." See Fig. 1. There are many other similar references in various books and articles on magnetism, but none are explicit as to the initial observation. It is reasonable to assume that artificial magnets were derived from natural magnets in the beginning of our knowledge of magnetism. That was the method given in the early records, and we certainly know it is one of the ways whereby we can obtain artificial magnets today, although we now have better and more effective methods. Until 1820, when Oersted discovered electromagnetism, all artificial magnets in practical use derived their virtues directly or indirectly from the natural magnets found on the earth.

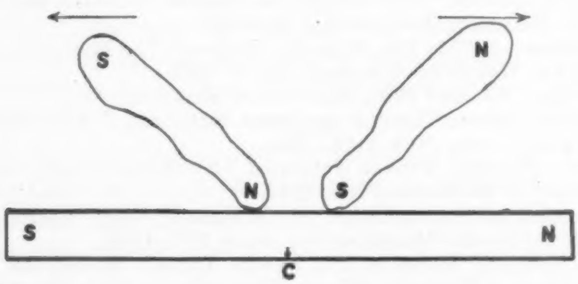


Fig. 12. The production of an artificial magnet of steel by stroking it with two pieces of magnetite.

A Method for Making an Artificial Magnet. A bar of steel, *SCN* Fig. 12, whose length is comparatively much greater than its other dimensions, is laid on a table. Two elongated pieces of magnetite are held, one in each hand, in such a position that the south seeking pole, *S*, of one and the north seeking pole, *N*, of the other are brought together in contact at the center, *C*, of the bar of steel. When contact is made between the two unlike poles of the magnetite and the center of the magnet, the two pieces of magnetite are then swept apart but still kept in contact with the steel bar to its very end. At the end of the stroke the two pieces of magnetite are lifted and returned in a circular sweep through the air and again contacted at *C*, Fig. 12. This process should be repeated several times, rubbing the unlike ends of the magnetite along the piece of steel. This is known as the "double touch" method. Fig. 13, *A*, shows a case where artificial magnets are being used to create other artificial magnets,

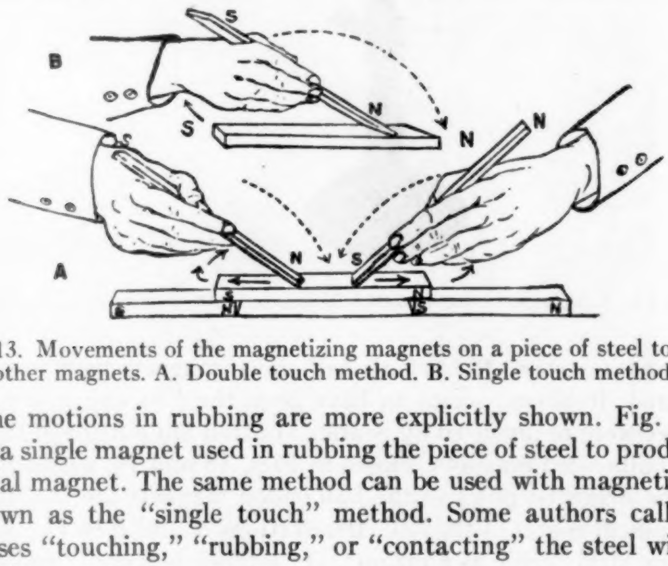


FIG. 13. Movements of the magnetizing magnets on a piece of steel to form other magnets. A. Double touch method. B. Single touch method.

and the motions in rubbing are more explicitly shown. Fig. 13, *B*, shows a single magnet used in rubbing the piece of steel to produce an artificial magnet. The same method can be used with magnetite and is known as the "single touch" method. Some authors call these processes "touching," "rubbing," or "contacting" the steel with the magnetite.

Once we get a clearer picture of what happens when a substance such as steel, or magnetite, becomes endowed with the power to attract small bits of iron to it, i.e., becomes magnetized, we shall see that, no matter what the process, it is all one and the same phenomenon which goes on inside of the material when it becomes magnetized. It will all be a matter of degree. The fact that we can get better and stronger magnets artificially from steel and some of its alloys than from natural magnets may be crudely illustrated by comparing Figs. 1 and 14. The artificial magnet supports five rings and the magnetite only three.

In the process of magnetization, just described, we have the means at our disposal to produce much longer and slimmer magnets than we were able to do with magnetite. There has grown up an idea that the longer and slimmer a magnet is, the nearer the magnetic poles are to the ends of the magnet. In a measure this is true, but it must be taken with a large grain of salt. In Fig. 15, *A*, is shown a magnetized steel knitting needle, whose ratio of length to diameter is greater than 125. Note, however, how far the magnetic poles are from the ends of the needle; also, where are they?

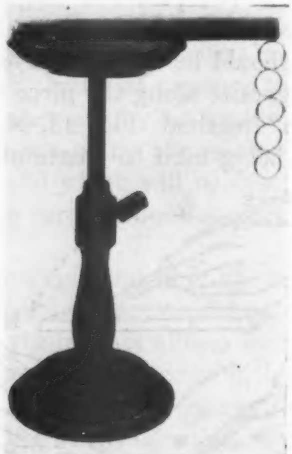


FIG. 14. Rings suspended from an Alnico magnet. Compare with Fig. 1.

In some quarters, Robinson's ball-ended magnets have been overestimated. Robinson seems to have been the first one to use them, but they were re-invented by Searle. The iron filing maps of the fields about ball-ended magnets, shown in Figs. 15 and 16, would indicate that the magnetic poles of the ball-ended magnets are far from the geographical center of the ball. Illustrations *A* and *B* in Fig. 15 show the same steel needle as a magnet; *A*, without ball ends, and *B*, with ball ends. There is some improvement in the distribution of the field about the ball-ended magnets but not to the degree that some would have us feel. However, again let it be emphasized that somewhere near the ends of the slim magnets there are force centers which are the locations of the magnetic poles, but they are not easy to establish. Fig. 16 shows the field about a nickel ball-ended magnet.

As our knowledge has increased concerning the behavior of magnets, one toward another, there has grown up a terminology regarding magnets which it is important to have clarified early in our study of magnetism.

Laws Which Govern the Attraction and Repulsion of Magnetic Poles

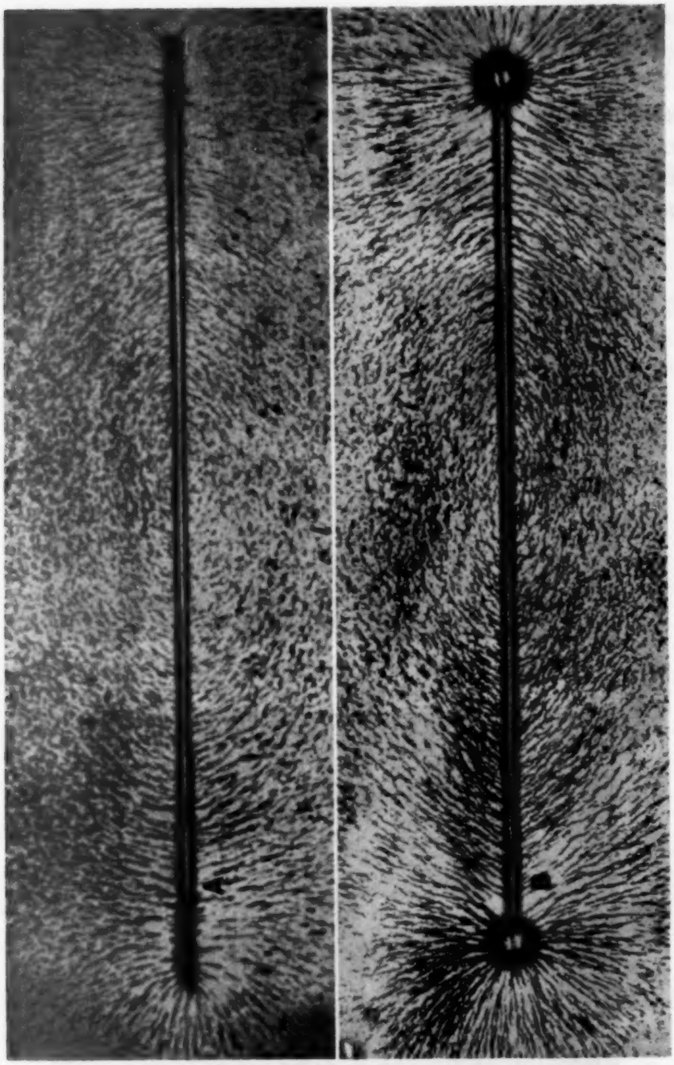


FIG. 15. The same knitting needle, A, as a permanent magnet without ball ends, B, with ball ends.

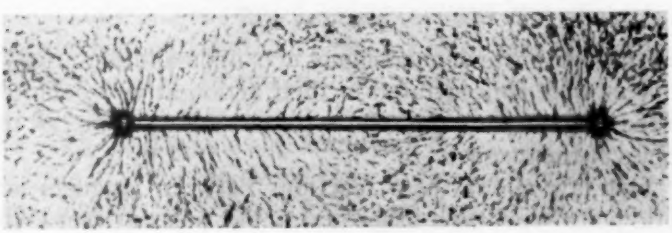


FIG. 16. A permanent nickel magnet with ball ends.

and the Directive Forces of Magnets. Artificial magnets can be made stronger, both mechanically and magnetically, than natural ones; also they can be formed to any desired shape much more easily, so that their use takes preponderance over the magnets found in nature. Pratically everything thus far said about natural magnets may be repeated about artificial ones, and, therefore, some things may be repeated in this chapter which were discussed in the preceding one.

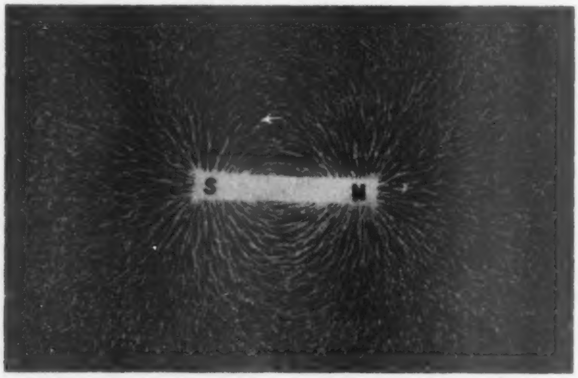


FIG. 17. Magnetic field about a single, artificial, steel magnet.

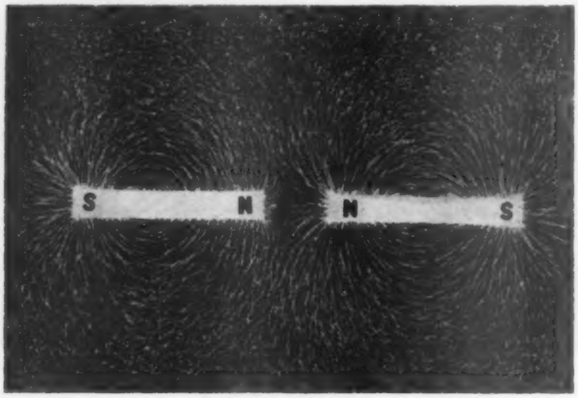


FIG. 18. Combination of the two magnetic fields from two artificial, steel magnets repulsion between like poles.

The forces with which one magnet acts upon another are as though these forces were concentrated in their action at two definite points within the magnets, and these force centers are what we call the magnetic poles of the magnet.

The first law about these reactions between magnets is:—Like magnetic poles repel each other and unlike poles attract. Why? We simply have no ultimate explanation. Later on we shall say that these

forces are due to the relative motions of the electric charges producing the magnetic fields, but even this does not get us back to ultimate reasons. We only know that these forces exist, and then observe how they attract and repel. The terms, south-seeking and north-seeking magnetic poles, are the same as for natural magnets.

Direction of a Magnetic Field. Another important observation is in regard to the direction of the magnetic fields of artificial magnets. Consider simply the lines of force as portrayed in Figs. 17 and 18. If one had not marked the poles definitely with N and S it would appear that one direction is as good as the other. We therefore define the direction of a magnetic field in a completely arbitrary fashion:— The direction of a magnetic field is that direction in which a positive or north-seeking magnetic pole will move in that magnetic field when

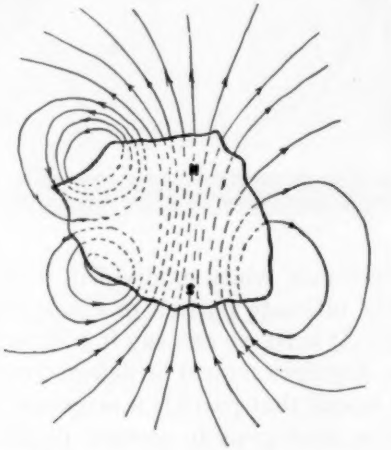


FIG. 19. Showing how the magnetic lines of force about the magnetite in Fig. 5 may be thought of as continuing through the magnetite.

left free to itself. A magnetic field is always attached to two magnetic poles, or a dipole, when we are considering the magnetic field of a magnet, and, therefore, a positive magnetic pole will move away from another positive pole and be attracted toward a negative pole. Hence, when the lines of force are drawn between a positive and a negative magnetic pole we can indicate the direction of the lines of force, or of the field outside the magnet, as being from a positive to a negative pole, and draw arrows to indicate that direction, as shown in Fig. 17. Thus we put into action Law I which says that a positive pole will repel a similar pole and attract an unlike pole. Furthermore, magnetic lines of force are closed lines of force as shown in Fig. 19, and do not, like electric lines of force, just begin and end on electric charges. Illustrations A and B, in Fig. 20, show an attempt to visual-

ize this difference. In A, Fig. 20, we see as many lines of force run into the magnetic pole as emerge from it. This is not the case for electric lines of force illustrated in B, Fig. 20. All of which takes us back once more to the isolated magnetic pole discussed in Chapter I and illustrated by Figs. 8 and 9. An isolated magnetic pole for artificial magnets is just as unthinkable as for natural magnets. If one continues this dividing indefinitely, as shown in Figs. 8 and 9, there must come

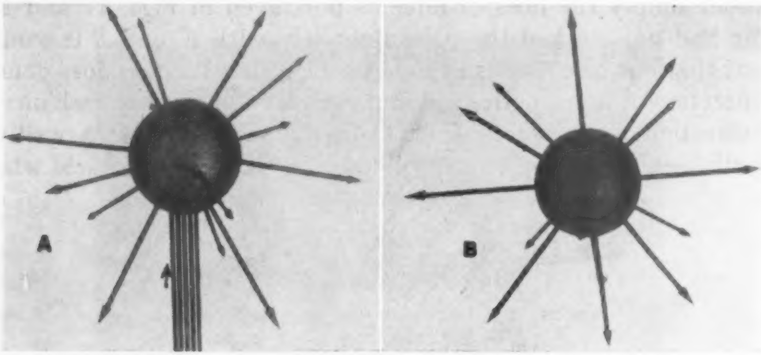


FIG. 20. Showing A. How magnetic lines of force enter and emerge from a positive magnetic pole. B. How lines of force simply emerge from a positive electric charge.

ultimately a particle which, when subdivided, does not produce two dipoles. What is that ultimate particle or configuration to be, which behaves in this way? At least we can say it will be the ultimate magnetic particle whose description must be deferred until a later chapter. For the present let us call that particle a *magneton*, once again trying to think in a fashion analogous to electric phenomena in that we called the ultimate electric particle the *electron*.

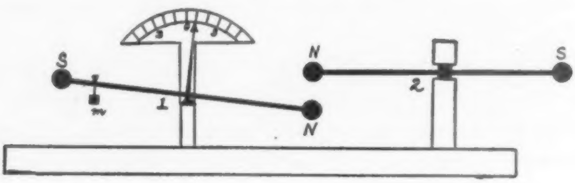


FIG. 21. Hibbert's magnetic balance.

To a fair degree isolated magnetic poles are realizable by using long, slim magnets. Thus, if we want to observe the effect of one N-pole on another N-pole, the use of long, slim magnets makes the effects of the two S-poles practically negligible on the forces which act between the two N-poles.

Coulomb's Law. That is exactly what Coulomb did when he established his law for magnetic poles—by means of a torsion balance which

he devised. A later version of this experiment is shown in Fig. 21 where a drawing is made of Hibbert's balance for confirming the law set up by Coulomb. It is assumed in this experiment of Hibbert's, as it was in Coulomb's, that such long, slim magnets were used to offset any influence which the other poles might exert on the two poles being tested. For all practical purposes the two outer poles, *S* and *S*, in the long magnets 1 and 2, Fig. 21, do not exert any influence on the forces acting between the two north-seeking poles, *N* and *N*. It can be seen in Fig. 21 that when the pointer of the balance beam is at zero on the scale, there is a definite distance *R* between the centers of the two magnetic north poles, *N* and *N*. By means of the sliding weight *m* the balance can always be brought to a position where the pointer stands at zero and thus the forces acting between the two

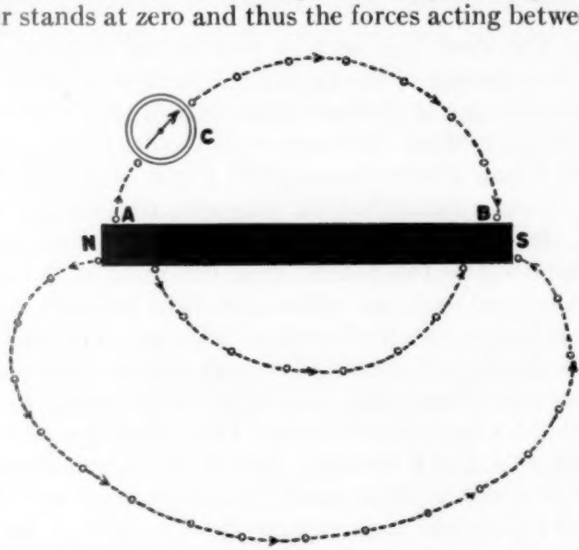


Fig. 22. Mapping the magnetic lines of force about a magnet by means of a compass, C, and pencil.

magnetic poles determined. In addition, various pole strengths may be given to *N* and *N* and thus the law as given by Coulomb reaffirmed.

With the establishment of Coulomb's law we can now define certain factors about magnets, more specifically for artificial magnets than we did for natural ones.

Another Method for Mapping Magnetic Fields. Lay a bar magnet on a large sheet of paper as in Fig. 22. Place anywhere in the field of the magnet a small compass needle, *C*. The latter will set its axis parallel to the direction of the field at the center of the compass needle. At each end of the compass needle place a small dot with the point of a pencil. A line between these two points will indicate the position of the axis of the needle. Now move the compass somewhat

parallel to the line already drawn on the sheet of paper and shift the compass until one of its poles stands directly over one of points or dots already made. Another dot made at the end of the compass needle farthest from the dot already made will again give a new position of the magnetic axis of the compass needle. Proceed in this way from one point, say A, until one runs into the magnet at B. When all of these successive dots are connected by a smooth line we shall have a magnetic line of force, or the path along which the magnetic force acts between A and B on the magnet. One may put in as many "lines of force" as he wishes and when completed they will compare favorably in appearance with the picture obtained by the iron filing method shown in Fig. 17. In no case can one magnetic line of force cross another line.

Ordinarily one does this sort of plotting of magnetic fields of magnets in the presence of the earth's magnetic field. When so done, the map is a resultant of the two fields, that of the earth's field and that of the magnet. When the magnet is parallel to the earth's field and with the N-pole directed toward the north, there will be formed equatorially about a cylindrical bar magnet a circular line where the resultant of the two fields is zero, whereas if the S-pole is toward the north there will be two points on an extension of the axis of the magnet, one beyond each end where zero field strength also occurs. It makes an interesting map when these fields are so plotted.

Unit Magnetic Pole. Coulomb's law may now be used for defining a unit magnet pole. This is done by making all quantities in the equation for Coulomb's law equal to unity. Thus m_1 and m_2 will be equal to unity when F, μ, and R are unity. Hence we define a unit magnetic pole as that pole which, when placed at a distance of one centimeter from another equal pole in a vacuum, ($\mu=1$), exerts a force of one dyne on that other equal pole.

This definition applies to natural magnets, as we have seen in Chapter I, because Coulomb's law was applicable both to natural and to artificial magnets.

Field Intensity or Strength of a Magnetic Field. About each magnet, and, therefore, about each (assumed) isolated magnetic pole, is a magnetic field whose strength or intensity we have defined as the force in dynes which that field exerts on a unit magnetic pole when placed at the point in the field where it is desired to know its strength. The formal definition is really derived from Coulomb's Law, which states that

$$F=\frac{m_1m_2}{R^2}$$

in a vacuum. If m_1 is made a unit magnetic pole, then F is the force

which the field of m_2 exerts on $m_1 = 1$ at a distance of R from it. Hence Field Intensity

$$H = F = \frac{1 \times m_2}{R^2} = \frac{m_2}{R^2}$$

in a vacuum. In any other medium.

$$H = \frac{m_2}{\mu R^2} \cdot$$

Interpreted, this equation says that the field intensity is proportional to the strength of the magnetic pole producing the field. Also the field intensity is inversely proportional to the square of the distance between the pole and the point considered, and inversely as the permeability factor μ which has not been discussed thus far.

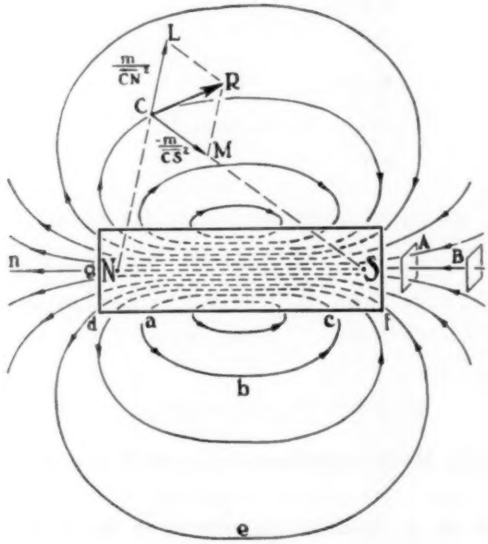


FIG. 23. Diagram illustrating direction of lines of force and field intensity. Taken from 4th Edition, 1933, Foley's *College Physics*. By courtesy of The Blakiston Company.

The unit for field intensity has been called the oersted, a designation given to it in honor of Oersted (1770–1851) who discovered the magnetic effect of an electric current, called electromagnetism, to be discussed in a later chapter.

Graphical Representation of the Direction of a Magnetic Field. Let a unit positive magnetic pole be placed at the point C in Fig. 23. It will be acted upon by both poles of the magnet N-S in such a way that the N-pole will repel the unit positive pole at C in the direction

CL, and the S-pole will attract along the path CM. The resultant of these two forces (represented by $CL=m/CN^2$ and $CM=m/CS^2$) will be the force represented by the vector CR, which gives not only a measure of its magnitude, but also its ***direction***. A tiny magnet placed at C will set its axis parallel to the line CR. It was on this principle that the plotting of the lines of force in the method given on p. 6, Fig. 22, was carried out.

Figure 23 shows how the lines of force run through a bar (artificial) magnet where some of them are shown as closed circuits. The others would also be closed were there space in which to draw them. This figure also shows graphically how the forces due to the poles of a bar magnet operate to give a resultant field intensity CR at the point C. It also illustrates at A and B how the lines of force at the S-pole converge, giving a different number of lines per square centimeter at B

FIG. 24. Mathematical evaluation of H at A and at B.

from what it is at A. In this drawing m is the pole strength of the magnet N-S.

Gauss's Proof of the Law of Inverse Squares. Gauss has given a simple but rigorous proof of the validity of the inverse square law used in Coulomb's law for magnetic poles. It is based on a comparison of the magnetic forces at two different points in the field of a ***short*** bar magnet. Thus in Fig. 24 is shown a small magnet, N-S. This will be the simplest problem possible to use the two points A and B to find the forces there due to N and S. Later a more general equation will be set up whereby the force at *any* point in the field of the magnet N-S will be derived.

In the present case the points A and B will be recognized as the tangent (A) and (B) positions of Gauss. Once more let it be noted

that we are using a fictitious, isolated, magnetic pole at the points A and B, to find the forces at A and B due to the small magnet. Later on we come to such real problems as (1) What is the force which one magnet exerts on another, or (2) What is the torque which one magnet exerts on another. There is nothing fictitious about real magnets, and yet an application of Coulomb's law to the forces and torques between magnets is the only means we have for solving such problems, and is a law based on isolated magnetic poles.

To Find the Magnetic Force H_A at a Point A on the Prolonged Axis of the Magnet. In Fig. 24, let A and B be points upon a circle whose center rests at O, the center also of the small magnet N-S. The distances OA and OB are equal, but very large with respect to the length of the small magnet N-S. The length of the magnet is $2l$ while $OA = OB = d$. The forces at A on a unit positive pole due to the poles of the magnet, will be

$$F_N = m/(d+l)^2$$

and

$$F_S = m/(d-l)^2.$$

The Total Force,

$$H_A = F_t = F_N + F_S = m/(d-l)^2 - m/(d+l)^2 = 4mld$$

a force acting toward O.

Since l is very small with respect to d, and $2ml = M$, the magnetic moment of the magnet N-S, the value of F_t becomes, when we neglect l^2,

$$H_A = F_t = 2M/d^3.$$

To Find the Magnetic Force H_B at the Point B, at Right Angles to the Axis of the Magnet. In an analogous fashion the forces at B on a unit positive pole, due to the two poles of the magnet N-S may be determined. The force due to N on the unit pole at B will be one of repulsion.

$$F_N = m/(d^2+l^2)$$

and directed along BD, while that due to S will be one of attraction along the line BC, and such that

$$F_S = m/(d^2+l^2).$$

Each one of the forces is resolvable into two components, one vertical and the other horizontal. The two vertical components, BF and BC annul each other, while the two horizontal ones, FC and GD, are in the same direction and add up to the value represented by BR. The

horizontal component of each force due to each pole will be equal to $FC=GD$.

$$GD/BD=OS/BS \quad \text{and} \quad GD=(BD\times OS)/BS$$

but

$$=\frac{m}{(d^2+l^2)}\times\frac{l}{\sqrt{d^2+l^2}}$$

Hence

$$=\frac{ml}{(d^2+l^2)^{3/2}}\,.$$

Inasmuch as both components act in the same direction, $2GD=BR$ and

$$BR=H_B=2ml/d^3=M/d^3$$

when l^2 is negligibly small with respect to d^2.

From a theoretical standpoint the force at B is $\frac{1}{2}$ that at A. This can now be put to the experimental test in a number of ways. Suppose one suspends first at A and then at B a tiny magnet carrying a mirror so that its deflections can be determined. What will be the magnitudes of the two deflections? We know that in using a deflecting magnet in this way the tangent of the angle of deflection is proportional to the deflecting force. In carrying out this experiment it has been found that

$$\tan\phi_A/\tan\phi_B=2.$$

Thus theory is confirmed by experiment, and since the theory was based on Coulomb's law, which carries the Inverse Square law in its formula, we have a rigorous proof of the validity of the Inverse Square law.

Another Experimental Method for Comparing Forces at A and B. On p. 477 it will be shown that the period of a swinging magnet is described by the equation

$$T=2\pi\sqrt{\frac{I}{MH}}\,.$$

If a small magnet is set into oscillation first at A and then at B, the ratio of the two periods will be

$$\frac{T_A}{T_B}=\sqrt{\frac{H_B}{H_A}}=\sqrt{\frac{1}{2}}\,.$$

Again it must be emphasized that these relations hold only in

cases where the value of l, the half length of the magnet, is very small with respect to d, the distance from the center of the magnet to the points being considered.

Quantitative Representation of a Magnetic Field Intensity. Figs. 17 and 18 showed a graphical representation of the magnetic fields about the magnetic poles of a single magnet and of a pair, respectively. There was nothing to indicate numerical values. Faraday, to whom we owe the ideas about graphical representation of magnetic fields, suggested that a magnetic field strength could be numerically represented by the number of lines of magnetic force drawn through a unit surface at right angles to the direction of the field. Thus in Fig. 25 is shown graphically the magnetic lines of force emerging from the N-pole of a magnet whose cross-section is one square centimeter. As indicated in the drawing, five lines of force emerge at right angles to the unit surface of the end of the magnet. Graphically, we have a magnetic field of 5 units (oersteds) near the surface of the end of the

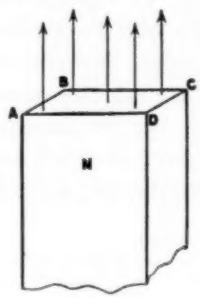


FIG. 25. Graphical representation of field intensity.

magnet. These lines of force begin to diverge as soon as they leave the surface in such a way that the inverse square law is obeyed for the values of the magnetic field intensity (strength). As we shall see later on, the inverse square law for a real magnet can hold only at distances which are great in comparison to the length of the magnet. In the illustration shown in Fig. 25, if a unit magnetic pole is placed near the surface indicated as normal to the lines of force, it will be acted upon by a force of 5 dynes.

Fig. 23 shows another example of designating a magnetic field strength by the number of lines passing through a unit area normal to the lines of force. At A the field strength is 3, while at B it is 1 oersted.

Lines of Force which Emanate from an Isolated North Pole. The visual method for indicating field intensity may now be applied to what occurs about a positive magnetic pole when isolated.

In the definition of a unit magnetic pole it was stated that a unit

magnetic pole exerted a unit force on a similar pole at a distance of one centimeter in a vacuum. This would mean that on a unit magnetic pole in a field intensity of one, the force would be one, and hence represented by one line per unit area. Draw about a unit magnetic pole a unit sphere, $r=1$ cm., let us say, and in the surface of that sphere the magnetic field intensity would be one. Since $r=1$, the area of the sphere would be 4π cm. and, therefore, for a field intensity of unity there would be one line per square centimeter and a total of 4π lines of force emanating from a unit magnetic pole. For any pole strength m there will be $4\pi m$ lines of force emanating from it. This factor $4\pi m$ is strongly entrenched in our theories of magnetism.

Thus, in speaking of lines of force as emerging or emanating from a magnetic pole, in no sense does one wish to leave the impression that something flows out of a positive pole or into a negative one. It is simply a way of indicating direction of a magnetic field which is a vector.

The Permeability Factor μ. This graphical representation also helps to visualize the meaning of μ which appeared in Coulomb's law for the forces between magnetic poles. Suppose we have a certain space in which a vacuum exists. Through this space let a certain number of magnetic lines of force pass, say N_0 lines per square centimeter. Now introduce into this same space another medium, and the number of lines per square centimeter N_1 will be different. The ratio of these two numbers,

$$\frac{N_1}{N_0}=\mu$$

is a measure, as we say, of the permeability of the substance replacing the vacuum for the magnetic lines of force. If $\mu>1$ the substance is classified as a paramagnetic substance, whereas if $\mu<1$ we have what is called a diamagnetic substance. There is a certain group of metals and alloys for which μ becomes very large, and which show unusual magnetic characteristics. These metals are iron, nickel, cobalt, and manganese, with many of their alloys. Among the alloys involving manganese may be mentioned the Heusler alloy.

This problem of what constitutes permeability will be discussed at greater length in Chapter VI, where the presence of dipoles will be thought of as the prime factor in the problem of permeability.

Thought of in terms of lines of force the paramagnetic substances seem to gather in the lines of force, while diamagnetic media seem to disperse them. This may be illustrated by A and B in Fig. 26. This leads to some curious movements of para- and diamagnetic bodies when placed in non-uniform fields. Paramagnetic bodies tend to move so as to contain the greatest number of lines of force per unit area,

or toward stronger fields, while the diamagnetic bodies tend to move toward weaker fields. As a general principle of dynamics, any body free to move in a magnetic field will so move that the potential energy of the system will be a minimum.

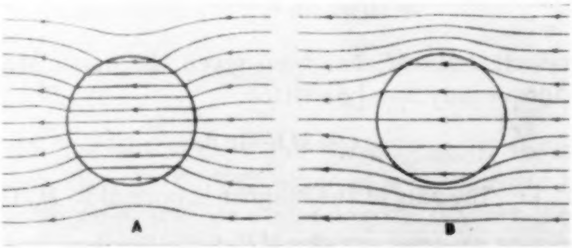


FIG. 26. *A* represents a paramagnetic substance and *B*, a diamagnetic. *A* is more permeable to magnetic lines of force than a vacuum. *B* is less permeable to magnetic lines of force than a vacuum.

Torque on a Magnet Due to a Magnetic Field. The force acting upon a unit magnetic pole was found to be

$$H=\frac{m_2}{R^2}$$

for a vacuum. For any pole strength m the force will be

$$F=Hm=\frac{mm_2}{R^2}\cdot$$

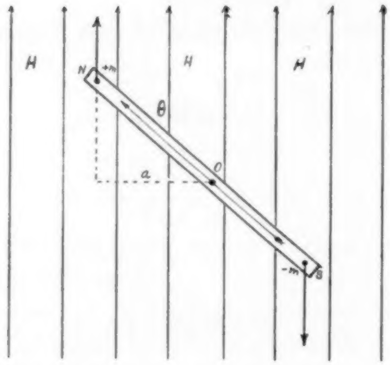


FIG. 27. A magnetic field, whose intensity is H, operates on a magnet tending to set the axis of the magnet parallel to the field.

Fig. 27 shows a bar magnet with its axis NS inclined at an angle θ with the magnetic field H. On the N-pole is a force $F_n=Hm$ and an equal force $F_s=Hm$ acting on the S-pole, both forces acting at an

arm's length a wherein $a=l \sin\theta$ and $2l$ is the distance between the two poles of the magnet N and S.

The two torques thus set up give a resultant torque

$$Q=Hml \sin\theta + Hml \sin\theta$$
$$=2Hml \sin\theta.$$

To the product, $2ml=M$, has been given the name Magnetic Moment. The torque may now be written

$$Q=MH \sin\theta.$$

If $\theta=90°$, i.e., the axis of the magnet is normal to H, then

$$Q=MH,$$

where M may be defined as

$$M=Q/H$$

the torque per unit field.

When $H=1$, $M=Q$, which says that the magnetic moment of a magnet is equivalent to the torque necessary to hold the magnet at right angles to a unit field.

While we have arrived at this defining equation $M=Q/H$ by the use of isolated magnetic poles, the final definition could have been made independently of any such conception.

In other words, the term *magnetic moment* is a very real factor in describing a magnet, and has especial significance as we inquire more deeply into the theory of magnetism.

Period of a Magnet Freely Suspended in a Uniform Magnetic Field. In the equation,

$$Q=MH \sin\theta$$

if θ is small, then

$$\sin\theta=\theta$$

in radians, and

$$Q=MH\theta=K\theta.$$

Inasmuch as Q varies as the angular displacement θ, (earmark of Angular SHM) the magnet will oscillate with simple harmonic motion. The general equation for SHM of rotation is

$$Q=\frac{4\pi^2 I\theta}{T^2}=MH\theta=K\theta$$

whence

$$T^2=\frac{4\pi^2 I}{MH}$$

or

$$T=2\pi\sqrt{\frac{I}{MH}}$$

where I is the moment of inertia of the magnet. If the magnet is a cylindrical bar, then $I=mL^2/12$ where m is the mass of the magnet and L is the length of the bar composing the magnet. The length L as used in finding I will not be exactly the same as $2l$ used in the relation—

$$M=2ml.$$

This is due to the fact that the magnetic poles of a magnet are not located exactly at the ends of the bar.

The Magnetic Length of a Bar-Magnet. Inasmuch as the $2l$ for the distance between the poles of a magnet is not as large as the length L of the magnet, it is desirable to see what may be done to discover an approximate ratio between the two lengths. This may be done by observing the deflections of a magnetometer when at different distances, d_1 and d_2, from the center of the magnet. From the relation for the two deflections, l may be calculated, for in the tangent (A) position of Gauss,

$$M/H=\frac{(d_1^2-l^2)^2\tan\alpha_1}{2d_1}=\frac{(d_2^2-l^2)^2\tan\alpha_2}{2d_2}$$

and

$$l^2=\frac{d_1^3\tan\alpha_1-d_2^3\tan\alpha_2}{2(d_1\tan\alpha_1-d_2\tan\alpha_2)}$$

$2l$ is the distance between poles, which is then compared with the actual length L of the magnet.

In the case of ordinary bar-magnets, the ratio of the magnetic length to the length of the steel bar is about 0.85.

IN MATHEMATICS TOO: LINGER AND LEARN

Lester H. Lange
Valparaiso University, Valparaiso, Indiana

Everybody seems to be in a hurry nowadays and, while a measure of haste in our affairs is often commendable, it is usually in our genuine interest to pause in order to reflect. In this paper we shall try to make this concrete by observing that all too often we hurry on after we have solved some particular mathematical problem, or have read someone else's solution, and fail to make the most of the learning situation that presents itself. Here we shall call attention to a problem discussed by W. W. Sawyer in his little book. *Mathematician's Delight*, and illustrate the educational value of *seeking alternative solutions and proofs*.

Sawyer, on page 66 of his book, presents in essence this problem: "Al and Betty work evenings. Al is off duty every ninth evening, Betty every sixth. Al is off duty this evening and Betty is off duty tomorrow evening. When, for the first time, if ever, will they be off duty the same evening?"

Sawyer then employs the following scheme to demonstrate the fact that under these conditions Al and Betty, quite unfortunately, cannot justifiably look forward to an evening date. See figure (1), where A means Al is off duty and B means Betty is off duty.

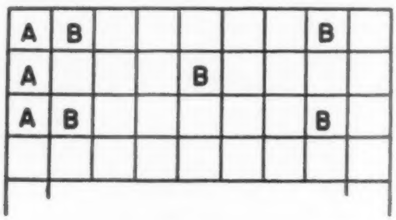


Fig. 1

Now this is fine, but here, as is very often the case with mathematical problems, (and this is hardly new to serious students of mathematics) much can be learned if we try to *discover other ways* to demonstrate a conclusion or solve a problem.

Here's a proof we might discover with only a little effort. It is a "reductio ad absurdum," a type of proof which must be mastered by every student of mathematics.

We notice that Al is off duty on evenings which are numbered 1, 10, 19, 28, $\cdots$, $9N+1$. Betty is off duty on evenings which are numbered 2, 8, 14, 20, $\cdots$, $6n+2$. We can now formulate our prob-

lem something like this: Is there an integer X such that both

$$9N+1=X$$

and

$$6n+2=X$$

where N and n are integers?

Let us assume that X exists. It then follows that

$$9N+1=6n+2$$

or

$$3(3N-2n)=1.$$

Now, for N and n integral, the expression $(3N-2n)$ is integral, say $(3N-2n)=I$. We are then faced with the conclusion that, if X exists, there is an integer I such that $3(I)=1$. But this is nonsense; hence our assumption must be false—the couple is in a bad way.

Not only have we had the pleasure of formulating and executing another proof, but we have formulated the problem in such a way as to enable us to solve readily a problem of the following type, namely, what happens if Betty is off duty every *fifth* evening? We then ask if it can be that

$$9N+1=5n+2$$

or

$$9N=5n+1.$$

Or, we could employ congruence notation* and ask if there is a solution to this congruence:

$$9N\equiv 4N\equiv 1 \pmod 5.$$

We need only consider N modulo 5, and we make the folowing table:

$$4\cdot 1\equiv 4 \pmod 5$$

$$4\cdot 2\equiv 3 \pmod 5$$

$$4\cdot 3\equiv 2 \pmod 5$$

$$4\cdot 4\equiv 1 \pmod 5.$$

Hence, the last entry in our table tells us, on the day numbered $9\cdot 4+1=37$ Al and Betty can look forward to an evening of celebration. Our table tells us further that any N which is congruent

* It seems that a great number of our schools do not manage to give students even a slight introduction to this highly desirable notation. For some observations in connection with this point see A FURTHER NOTE below.

to 4 modulo 5 is a solution. Thus, the first few values for N are $N=4,9,$ 14 and 19, these values yielding the days which are numbered

$$9\cdot 4+1=37$$
$$9\cdot 9+1=82$$
$$9\cdot 14+1=127$$
$$9\cdot 19+1=172.$$

If we wish, we can check our work by employing a scheme like Sawyer's. We then construct the pattern of figure (2).

A	B					B		
A		B					B	
A			B					B
A				B				
AB					B			

FIG. 2

Nor need we rest here. If perchance we happen to know a minimal amount of the theory of congruences, we could state our first problem in this manner: Is there an integer x such that

$$x\equiv 1 \pmod 9$$

and also

$$x\equiv 2 \pmod 6?$$

Now, in the theory of congruences there is an elementary theorem which says that a *necessary* condition for the existence of a solution to the system

$$x\equiv a \pmod m$$
$$x\equiv b \pmod n$$

is that

$$a\equiv b[\text{mod } (m, n)]$$

where the notation (m, n) means, as usual, the greatest common divisor of m and n.

Thus we have an easy way to show that the couple will be disappointed, for, since $(9, 6)=3$, we observe that $1\not\equiv 2 \pmod 3$ and the system is shown to have no solution.

Furthermore, in the second case we *are* justified in looking for a solution since we are to solve the system

$$x \equiv 1 \pmod 9$$
$$x \equiv 2 \pmod 5.$$

Here $(9, 5) = 1$, *i.e.*, they are co-primes and certainly $1 \equiv 2 \pmod 1$.

Finally, the *inherent generality* of our search for the solution in the latter case tells us that if we linger we may give ourselves the chance to learn.

A FURTHER NOTE: While many of us may not be familiar with congruence notation, some may be familiar with a scheme for solving what are known as "indeterminate equations" as discussed, for example, in *Higher Algebra*, by Hall & Knight (Macmillan, London, 1891). (See pp. 110–113 and pp. 284–291.) We shall proceed to solve our present problems in the fashion indicated in Hall & Knight—not merely to show the method they discuss, but to illustrate the benefits of the congruence notation we have employed above.

In the first case, then, we seek integer values of n and N which satisfy

$$9N+1=6n+2$$
$$6n=9N-1$$
$$n=\frac{9N}{6}-\frac{1}{6}$$
$$n=N+\frac{3N}{6}-\frac{1}{6}\cdot$$

If we let K stand for the integer $(n-N)$, we have

$$K=\frac{3N-1}{6}$$
$$6K=3N-1$$
$$3N=6K+1$$
$$N=2K+\frac{1}{6}\cdot$$

Since there are clearly no integers N and K which satisfy this last equation, we have again demonstrated the fact that there exists no solution in this case.

In the second case, we consider

$$9N+1=5n+2$$
$$5n=9N-1$$

$$n=\frac{9N}{5}-\frac{1}{5}$$

$$n-N=K=\frac{4N}{5}-\frac{1}{5}$$

$$5K=4N-1$$

$$4N=5K+1$$

$$N=\frac{5K}{4}+\frac{1}{4}$$

$$N-K=L=\frac{K}{4}+\frac{1}{4}$$

$$4L=K+1$$

or

$$K=4L-1.$$

The various solutions are then arrived at by assigning values to L. We might then make the table:

L	K= 4L−1	N= L+K	n= K+N	Celebration Days
0	−1	−1	−2	−8
1	3	4	7	37
2	7	9	16	82
3	11	14	25	127

FIG. 3

Now the essential part of this latter work is in the statement

$$5K=4N-1$$

or

$$5(4L-1)=4N-1.$$

This reduces to

$$5L-1=N$$

or, as we wrote it earlier

$$N\equiv -1\equiv 4 \pmod 5.$$

Notice how this last statement actually enables us to avoid the more extensive tabular work and we can immediately write

$$N=4, 9, 14, \cdots.$$

We also note that we can easily establish that the proper values for n are

$$n \equiv 7 \pmod 9), \text{ i.e.,}$$
$$n = 7, 16, 25, \cdots.$$

THE TYPE OF COLLEGE GRADUATE DESIRED BY A MANUFACTURING INDUSTRY*

KENNETH A. MEADE

Director, Educational Relations Section, Public Relations Department, General Motors Corporation, Detroit, Michigan

I am glad to have this opportunity to meet with you, to see again many of my friends in Kalamazoo and to meet you educators who are responsible for higher education in Michigan. In General Motors we are very interested in education. We employ many of your graduates each year and we are anxious to help in whatever way we can in the educational process.

I will attempt this morning to give you the viewpoint of manufacturing industry and of General Motors in particular on the products you produce—your graduates. To start with, I thought you might be interested in a few statistics as to the number of graduates we employ. In a survey we made at the end of June, 1951, the reports from all our operations showed that we had 7,149 graduate engineers; 4,010 business administration graduates; and, 3,431 graduates of liberal arts and other courses. These figures include the graduates of General Motors Institute. While about 50% of this group are engineers, which is quite natural when you consider the kind of business we are in, you will note the business graduate and those with more general education play an important part in our organization.

From the same survey, we have the following picture of graduates of colleges and universities in Michigan who were in our employ at that time. From General Motors Institute, 1,902; from the seven colleges and universities with engineering courses, 2,188; from the colleges of education, 118; and from the private church affiliated colleges, 110; and, from others, 23—giving a total of 2,439 or about 17% of the total college graduates from Michigan institutions employed in G.M. I believe this speaks well for the job the people in higher education in the State of Michigan are doing.

This group is added to each year. The college graduate recruiting

* This talk was given in Kalamazoo, February 12, before a section of the Department of Higher Education of Michigan Education Association.

section of our Personnel Staff makes annual visits to more than 100 colleges and universities to recruit prospects for employment in General Motors. In carrying out this responsibility they do not employ the graduates, but screen them and make recommendations to our Staffs and Divisions. Under our decentralized operating policy the individual units of General Motors have the final responsibility for selecting the individual graduates they wish to employ. Over the years, the men responsible for the selection of these graduates have set up certain criteria to guide them.

It has always been very interesting to me when listening to representatives of industry talk to educators or educators speak to folks in business and industry about the products of the schools. The same points are usually stressed, but the terminology each group uses is quite different.

A representative of business or industry, when speaking to a group of educators on the subject "What Does Business and Industry Expect of the Schools," will probably make frequent use of the terms "fundamentals," "good citizenship," "teamwork," and "good work habits." He may have developed "yardsticks" which he feels can be used to measure how well students—the products of the educational institutions—are prepared to enter the working world and take their place in adult society.

On the other hand, when an educator speaks to a group of business and industry people, he quite frequently discusses methods used in schools to develop the student which, in his opinion, can best fit the student to take his place in society. The educator will probably refer to "life adjustment programs," "evaluation techniques," "progressive methods" and the importance of fitting the "curriculum" to the needs of the student.

Now, when we stop to analyze the real meaning of what each has said, and take into account the background of experience and viewpoint of each, I am sure you will agree with me that both education and industry have the same ideas in mind.

In the first place, it is our experience that the accredited institutions of higher education are generally doing an excellent job in giving their students a fundamental background on which to build experience when they take their place in industry and in life. Education by itself will not give the graduate an escape from routine, from hard work, from responsibility or the possibility of economic difficulties. It will not guarantee him economic security, success or happiness in his job. It can, however, train him to work with his hands or with his brain or both. It can help him to develop a willingness to accept responsibilities as regards his job, family, and fellow citizens and it can help him to develop an ability to make adjustments in getting along

with and living in a friendly and peaceful manner with all of the people with whom he is associated. It should also help him to develop a faith in God and a habit of asking His help in solving the many problems that will confront him during his working life. These, in our opinion, should be the aim of education.

Very few of the unsuccessful college graduates I have known in industry failed to progress because of insufficient technical skill or ability. Many have been found lacking in personality or personal characteristics and their lack of development classed as a professional failure. We try to avoid such mistakes by placing most of the emphasis in our interviews on the observation and appraisal of the applicant's attitudes and personal qualifications.

We look for the graduate with above average mental ability because he will be up against stiff competition. We want individuals who are physically, mentally and emotionally mature. We are interested in graduates who have demonstrated that they are good team workers; who show a spirit of cooperation; and, who have developed an attitude of service rather than the feeling that we owe them a position or a livelihood. Finally, we are much more interested in the graduate who wants an opportunity to compete with others like himself and who is looking for an opportunity to develop himself for whatever responsibilities that may come his way rather than the one who expresses a primary interest in job security and our pension plans before he is placed on the payroll.

It should be obvious that any large corporation is an organization of many people in which no single individual is apt to reach his personal objective without the voluntary cooperation and assistance of his associates. Experience has demonstrated many times that the degree of cooperation is determined by the personality factor more than anything else. Modern industrial progress depends on teamwork to such a degree that the graduate must be able to submerge his individuality to a considerable extent in order to become an effective member of that team. As a member of the team, he must be capable of making his own contributions, yet be flexible enough to change his own ideas as new thoughts are presented to him by other members of the groups. Few indeed are the industrial positions wherein an employee can work as a "lone wolf." If he honestly wishes to progress, he must be able to adapt himself to the organization in a wholehearted manner. He must learn to work with people until his responsibilities increase to such an extent that the major requirement is for people to work with him.

Therefore, much of the executive effort going into our development program for the college graduates we employ aims at the goal of influencing and correcting personality and professional characteristics

which, if left unchecked, could and probably would have an adverse influence on the individual's future progress in the organization. This is a difficult task, but the results justify a great deal of effort.

Now for a few suggestions as to how we might improve the quality of these graduates. In the automobile business as you know, we come out with new models each year. Our engineers feel that each of these is the best that was ever produced and they are right. By carrying on a continuous long-range research and development program, we can take advantage of new information and thus constantly improve our products. So in education by continuous development of selection techniques, teaching methods, and instructional material, we can each year put out the best models ever produced.

In improving your programs, I suggest you stick to training in fundamentals rather than trying to develop students for a narrow specialized field or occupation. In industry we are equipped to help those graduates we employ continue their training and development.

However, whenever possible, use practical instructional material that is available from business and industry as case examples to acquaint the student with what he will encounter in a job so that his adjustment from college to industry will be easier.

Help the student to understand the full meaning and purpose of his education rather than looking at it as a collection of individual courses with little integration.

Help the student to develop the habit of periodically making an inventory of his abilities, interests and personal qualifications so that he can make an intelligent choice of a career. Let him proceed as fast in obtaining his formal education as his health and ability will permit.

Since much of what the student learns in school and later on the job as an employee and in his everyday pursuits will be learned from his observation of the way other people do things, he should be trained as early as possible in how to observe and how to evaluate what he observes.

Finally, we hope that you will continue to emphasize the importance of English, report writing and oral expression. These not only help to develop well rounded individuals, but will make him better able to sell himself and his ideas.

To summarize, we believe that the essential components of a successful career in General Motors can be reduced to just three requirements on the part of the young graduate:

1. Native abilities such as health, energy, imagination, intelligence, initiative and comparable characteristics.
2. Ability to use the known laws of the arts and sciences—as you have taught him to do in his formal education.

3. An understanding and ability to apply the "unwritten laws" by which his own efforts are integrated into the large field of industrial endeavor.

Free education as designed for the first time by the founders of this country has contributed importantly to America's greatness until today education in all its phases is one of the most important foundations of our way of life. It is vitally concerned with today's youth who will be the political, business, educational and industrial leaders of tomorrow. I am sure that all of us working together, each making the contributions he is best qualified to make, will preserve and improve our educational program.

SKULL-DIGGERY

ALFRED J. CHISCON
State Teachers College, Bloomsburg, Pa.

In our progressive era of visual education, a collection of vertebrate skulls to be used for demonstration of cranial structure can be easily acquired with little or no strain on that hectic budget. All that is needed is a little time, simple labor, and a bit of cooperation from friends, neighbors, and students.

FIG. 1. Placed on a window sill in the hands of nature, decay and ravenous bugs make short work of the flesh of any skull.

The school biology laboratory or even the basement at home can serve as a "Skull-diggery." A set of dissecting tools, a metal basin, a source of heat, and a bottle of carbon tetrachloride will suffice as the main necessary equipment.

Each year brings with it seasons of hunting and trapping, together

with the accompanying absences from the classroom. A broad hint dropped a short time before these seasons occur will seldom go unnoticed. The normally discarded head of the kill becomes a tool of drawing the teacher's favor, and the average student, whether he,

FIG. 2. Removing what nature had no time to remove, a laboratory assistant prepares a deer skull for masceration.

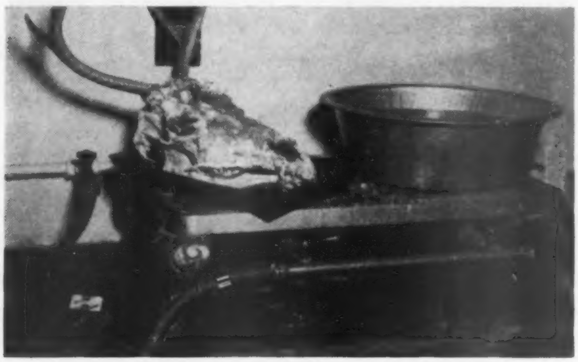


FIG. 3. Ready to be placed in a pan of hot water, the skull will quickly lose its flesh.

his parents, or friends hunt, will haul in a specimen or two if any are at all available. Inquiries in the neighborhood may also bring results from other sources.

Upon obtaining the specimens, the next step depends on how long you desire to await a finished product. If time is of no hindrance, the work becomes simpler. Just place the head in an uncovered wooden box and leave the rest to nature. Up in a tree, on a window sill of a seldom used portion of a house or building, in a field, anywhere away from normal wanderings is an ideal location. Natural decay and the insatiable hunger of bugs and insects will clean almost all flesh from the skull in a comparatively short period of time.

If more haste is desired, the skull must undergo the process which is called "fleshing." By that is meant the removal of the skin, viscera, and as much muscle tissue as can be quickly accomplished with merely the aid of knives, scissors, and scrapers.

FIG. 4. Finished products. Fleshed skulls, professionally creamy white, make perfect demonstration specimens.

After either the slow or speeded method is used, the skull must then undergo another process known as "masceration." Again more than one method is available. The fleshed head may be placed in water and left for several days in a warm place. Cultures of bacteria will develop and begin to digest the muscle tissue which adheres to the bone. For quicker results, the head may be almost boiled in hot water until the tissue softens and begins to come away from the skull. For perhaps most perfect results, the head could be placed into an aqueous solution of caustic soda. In all three cases, however, the process of masceration has advanced far enough when the flesh can be easily rubbed away from the bone with the fingers.

Following masceration, remove the skull and take all the remaining

shreds of tissue from the bone. A stiff brush dipped frequently in hot water will prove effective. After shredding, wash the skull well in running water and allow it to dry thoroughly. While a good specimen may often be obtained after this is done, many times the bones will be grayish in color, with here and there a greasy, discolored area. To remove this grease, fat, and oil, the head should be placed in some volatile grease solvent such as carbon tetrachloride. When all grease has been removed, the skull can then be removed to a bleaching compound from which it will emerge a uniform, creamy white color.

The teacher need not rely totally on hunting season for a supply of specimens. Bird heads always can be obtained from those killed or found dead. Farmers can be contacted for any casualties they might have. Again, students can themselves furnish an almost unlimited and varied supply.

In you own science department, therefore, a collection of skulls can be easily started. Establishing your own "Skull-diggery" is no skullduggery; it's no trick at all. It's simple to make headway by using that head.

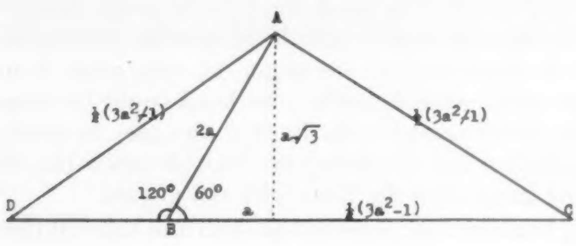
ECONOMY IN LEARNING

W. A. Ownbey

A valuable device to aid students in mastering a new concept or skill in mathematics is that of making everything else easy, so easy that the student can put his entire attention to the one thing to be learned.

There are many possible illustrations of this. One is in the use of the Law of Cosines for finding an angle when the three sides of a triangle are given. It is best at the beginning of this study to use for the sides integers that will give a simple cosine ratio for the angle, say $\frac{1}{2}$ or $-\frac{1}{2}$, thus avoiding awkward fractions and decimals with their interpolations for finding the approximate angle. At the conclusion of the study, interpolations should be involved.

One simple formula that will give 60° or 120° for the angle follows:

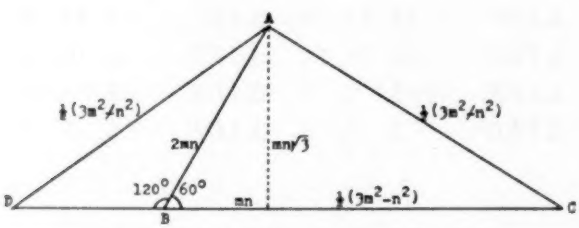


Here are a few substitutions for ΔABC, $\angle B$ being a 60° angle:

Substitutions	AB	BC	CA	Integral ratios of		
a	$2a$	$\frac{1}{2}(3a^2-1)+a$	$\frac{1}{2}(3a^2+1)$	AB	BC	CA
3	6	16	14	3	8	7
5	10	42	38	5	21	19

Substitutions for ΔABD, $\angle B$ being a 120° angle:

Substitutions	AB	BD	DA	Integral ratios of		
a	$2a$	$\frac{1}{2}(3a^2-1)-a$	$\frac{1}{2}(3a^2+1)$	AB	BD	DA
2	4	$3\frac{1}{2}$	$6\frac{1}{2}$	8	7	13
7	14	66	74	7	33	37

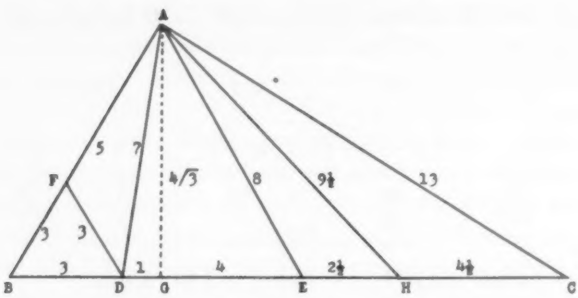


A more general formula, based on the above figure and illustrating the many possibilities of the device, follows for ΔABC, with $\angle B = 60°$:

m	n	AB	BC	CA	AB,	BC,	CA
		$2mn$	$\frac{1}{2}(3m^2-n^2)+mn$	$\frac{1}{2}(3m^2+n^2)$			
2	1	4	$7\frac{1}{2}$	$6\frac{1}{2}$	8,	15,	13
2	3	12	$7\frac{1}{2}$	$10\frac{1}{2}$	8,	5,	7
2	5	20	$3\frac{1}{2}$	$18\frac{1}{2}$	40,	7,	37
3	2	12	$17\frac{1}{2}$	$20\frac{1}{2}$	24,	35,	41

For ΔABD, with $\angle B = 120$:

m	n	AB	BD	DA	AB,	BD,	DA
		$2mn$	$\frac{1}{2}(3m^2-n^2)-mn$	$\frac{1}{2}(3m^2+n^2)$			
3	1	6	10	14	3,	5,	7
3	2	12	$5\frac{1}{2}$	$15\frac{1}{2}$	24,	11,	31
4	1	8	$19\frac{1}{2}$	$24\frac{1}{2}$	16,	39,	49
5	1	10	32	38	5,	16,	19



The above figure is a pattern of overlapping triangles with their sides having some of the simpler ratios for triangles with angles of 60° or 120°. It could be used as an interesting study of the Law of Cosines.

It offers the following triangles, the letter at the 60° or 120° angle being underlined in each case.

$\Delta A\underline{B}C$	· · · 15, 13, 8	$\Delta A\underline{E}C$	· · · 7, 13, 8
$\Delta A\underline{B}H$	· · · 21, 19, 16	$\Delta A\underline{E}H$	· · · 5, 19, 16
$\Delta A\underline{B}E$	· · · 1, 1, 1	$\Delta AD\underline{E}$	· · · 5, 8, 7
$\Delta A\underline{B}D$	· · · 3, 7, 8	$\Delta AD\underline{F}$	· · · 3, 5, 7

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2331, 5, 9, 40. *C. W. Trigg.*

2344. *Merle Weitz, Denver; M. P. Bridges, West Roxburg, Mass.; V. C. Bailey, Evansville, Ind.*

2347. *Proposed by C. W. Trigg, Los Angeles City College.*

P is any point on the incircle of a regular n-gon. Show that the sum of the squares of the distances from the vertices of the n-gon is $n(r^2+R^2)$, where r, R are the radii of the inscribed and circumscribed circles, respectively.

Solution by C. W. Trigg, Los Angeles City College

This is a generalization of problem 2288, This Magazine, May 1952, page 408. Let the vertices of the regular polygon be $A_1, \cdots, A_n$ with A_1 the nearest vertex clockwise from P. Let the midpoint of A_iA_{i+1} be B_i and let angle POB_1 be α. Then

$$(PA_i)^2+(PA_{i+1})^2=2(PB_i)^2+2(s/2)^2,$$

whence

$$2\sum (PA_i)^2=2\sum (PB_i)^2+2n(s/2)^2.$$

But

$$(PB_1)^2=r^2+r^2-2r^2\cos\alpha, \qquad (PB_2)^2=r^2+r^2-2r^2\cos(\alpha+2\pi/n),$$

etc. Hence,

$$\sum (PB_i)^2=2r^2\{n-\cos\alpha-\cos(\alpha+2\pi/n)-\cos(\alpha+2\cdot 2\pi/n)-\cdots$$
$$-\cos(\alpha+[n-1]2\pi/n)\}$$
$$=2r^2\{n-\cos[\alpha+(n-1)\cdot\pi/n][\sin n\cdot 2\pi/2n]/\sin 2\pi/2n\}$$
$$=2r^2n.$$

Therefore,

$$\sum (PA_i)^2=2r^2n+n(s/2)^2=n[r^2+r^2+(s/2)^2]=n(r^2+R^2).$$

A solution was also offered by Richard H. Bates, Milford, N. Y.

2348. *Proposed by Leon Bankoff, Los Angeles.*

Show that $\cos 10\theta-\cos 11\theta$ is divisible by $2\cos 7\theta+1$ and find the other factor.

Solution by Jesse B. Flansburg, Houston, Texas

Using the formula for the difference of cosines

$$\cos 10\theta-\cos 11\theta\equiv 2\sin\frac{21\theta}{2}\sin\frac{\theta}{2}; \quad \text{or}$$

$$\text{since} \quad \sin 3x\equiv 3\sin x-4\sin^3 x,$$

$$\cos 10\theta-\cos 11\theta\equiv 2\left(3\sin\frac{7\theta}{2}-4\sin^3\frac{7\theta}{2}\right)\sin\frac{\theta}{2}$$

$$\equiv 2\sin\frac{7\theta}{2}\sin\frac{\theta}{2}\left(3-4\sin^2\frac{7\theta}{2}\right). \tag{1}$$

Now, using the "double-angle" formula

$$2\cos 7\theta+1\equiv 2\left(1-2\sin^2\frac{7\theta}{2}\right)+1$$

$$\equiv 3-4\sin^2\frac{7\theta}{2} \tag{2}$$

(2) is clearly a factor of (1), the other factor being $2 \sin (7\theta/2) \sin (\theta/2)$ or $\cos 3\theta - \cos 4\theta$.

Solutions were also offered by William C. Lowry, Columbus, Ohio; Richard H. Bates, Milford, N. Y.; James Gray, San Antonio; Martin Schmookler, Scranton, Pennsylvania; R. L. Moenter, Fremont, Nebraska; David Rappaport, Chicago; C. W. Trigg, Los Angeles City College.

***2349.** *Proposed by C. W. Trigg, Los Angeles City College.*

Find five different fractions, each of the form $m/(m+1)$ such that their sum is an integer.

Solution by the Proposer

For each of the different fractions, f, $\frac{1}{2} \leq f < 1$. Therefore, $\frac{5}{2} < \sum f < 5$. Indeed $\frac{1}{2}+\frac{2}{3}+\frac{3}{4}+\frac{4}{5}+\frac{5}{6}=\frac{213}{60}>3$, so $\sum f=4$. Let the distinct numerators of the fractions, arranged in order of increasing magnitude, be m, n, p, q, r. Now $\frac{3}{4}+\frac{4}{5}+\frac{5}{6}+\frac{6}{7}+\frac{7}{8} =\frac{3457}{840}>4$, so $m=1$ or 2.

Case I. $m=2$. $n/(n+1)+p/(p+1)+q/(q+1)+r(r+1)=10/3$. Now $\frac{4}{5}+\frac{5}{6}+\frac{6}{7}+\frac{7}{8} >\frac{10}{3}$, so $n=3$. That is, $p/(p+1)+q/(q+1)+r/(r+1)=10/3-\frac{3}{4}=\frac{31}{12}<\frac{6}{7}+\frac{7}{8}+\frac{8}{9}$, so $p=4$ or 5.

If $p=4$, $r=(47q+107)/(13q-47)=3+8(q+31)/(13q-47)$. The sole solution of this equation for $4<q<r$ is $q=5$, $r=19$.

If $p=5$, $r=(3q+7)/(q-3)=3+16/(q-3)$. This equation has no solution for $5<q<r$.

Hence the unique solution for this case is $\frac{2}{3}+\frac{3}{4}+\frac{4}{5}+\frac{5}{6}+\frac{19}{20}=4$. This may be represented as $(m, n, p)=(2, 3, 4)$; $(q, r)=(5, 19)$.

Case II. $m=1$. $n/(n+1)+p/(p+1)+q/(q+1)+r/(r+1)=\frac{7}{2}<8873/2520=\frac{6}{7}+\frac{7}{8}+\frac{8}{9}+\frac{9}{10}$, so $n=2, 3, 4$, or 5.

If $n=2$, $p/(p+1)+q/(q+1)+r/(r+1)=\frac{17}{6}<\frac{17}{18}+\frac{18}{19}+\frac{19}{20}$. Otherwise $r=[q(5p+11)+11p+17]/[q(p-5)-(5p+11)]$, so $p=6, 7, \cdots, 15$, or 16.

If $p=6$, $r=(41q+83)/(q-41)=41+1764/(q-41)$. The solutions of this equation for $6<q<r$, are $q=42$, $r=1805$, etc. as given below.

Proceeding in like manner to search for all possible solutions, we find the 70 sets of five integers which determine five different fractions of the form $m/(m+1)$ whose sum is an integer (in each case, 4). The sets are:

(m, n, p)	(q, r)
(1, 2, 6)	(42, 1805), (43, 923), (44, 629), (45, 482), (47, 335), (48, 293), (50, 237), (53, 188), (55, 167), (59, 139), (62, 125), (69, 104), (77, 90).
(1, 2, 7)	(24, 599), (25, 311), (26, 215), (27, 167), (29, 119), (31, 95), (32, 87), (35, 71), (39, 59), (41, 55).
(1, 2, 8)	(18, 341), (19, 179), (20, 125), (21, 98), (23, 71), (26, 53), (29, 44).
(1, 2, 9)	(15, 239), (17, 89), (19, 59), (23, 39).
(1, 2, 10)	(13, 230), (14, 109), (21, 32).
(1, 2, 11)	(12, 155), (13, 83), (14, 59), (15, 47), (17, 35), (19, 29), (20, 27).
(1, 2, 13)	(14, 34).
(1, 3, 4)	(20, 419), (21, 219), (23, 119), (24, 99), (27, 69), (29, 59), (35, 44).
(1, 3, 5)	(12, 155), (13, 83), (14, 59), (15, 47), (17, 35), (19, 29), (20, 27).
(1, 3, 6)	(9, 139), (11, 41).
(1, 3, 7)	(8, 71), (9, 39), (11, 23).
(1, 3, 8)	(11, 17).
(1, 4, 5)	(7, 119), (8, 44), (9, 29), (11, 19).
(2, 3, 4)	(5, 19).

Solutions (not complete) were offered by William C. Lowry, Columbus, Ohio; R. L. Moenter, Fremont, Nebraska; Martin Schmookler, Scranton, Pennsylvania.

2350. *Proposed by Margaret F. Willerding, Harris Teachers College, St. Louis.*

Use (a) the half-angle formula and (b) the formula for the difference of two

angle to find the sine 15°. Prove that these two radical forms are equivalent.

Solution by the proposer

$$\sin 15° = \sin 30°/2 = \frac{\sqrt{2-\sqrt{3}}}{2}$$

$$\sin 15° = \sin (45° - 30°) = \frac{\sqrt{6}-\sqrt{2}}{4}.$$

Now show:

$$\frac{\sqrt{6}-\sqrt{2}}{4} = \frac{\sqrt{2-\sqrt{3}}}{2}.$$

The left number becomes:

$$\frac{\sqrt{(\sqrt{6}-\sqrt{2})^2}}{4} = \frac{\sqrt{8-4\sqrt{3}}}{4} = \frac{2\sqrt{2-\sqrt{3}}}{4} = \frac{\sqrt{2-\sqrt{3}}}{2}.$$

Solutions were also offered by Cecil B. Read, University of Wichita; Bessie Leyburn, Cato, N. Y.; Walter R. Warne, Syracuse, N. Y.; C. W. Trigg, Los Angeles City College; R. L. Moenter, Fremont, Nebraska; Bro. James F. Gray, San Antonio; Richard H. Bates, Milford, N. Y.; Lester Moskowitz, New York; Mart E. Mitchell, Plainfield, Illinois; William C. Lowry, Columbus, Ohio; Leon Bankoff, Los Angeles; David Rappaport, Chicago; George R. Dixon, Ellenville, N. Y., Harry Hickey, Davidson, N. C.; Martin Schmookler, Scranton, Pa.

2351. *Proposed by Roy Wild, University of Idaho.*

If $f[f(x)] = x^2$, find $f(x)$.

Solution by Martin Schmookler, Scranton, Pa.

Let $f(x) = x^n$. Then $f[f(x)] = (x^n)^n = x^{n^2}$.

But $f[f(x)] = x^2$. Hence $n^2 = 2$, $n = \pm\sqrt{2}$.

So $f(x) = x^{\pm\sqrt{2}}$.

Solutions were also offered by R. L. Moenter, Fremont, Nebraska; Charles W. Trigg; James F. Gray, San Antonio and the proposer; Harry W. Hickey, Davidson, N. C.; Martin Schmookler, Scranton, Pa.

2352. *Proposed by A. R. Haynes, Tacoma, Washington.*

Show by elementary geometry that the sides of any triangle ABC bisect the exterior angles of its pedal triangle.

Solution by Leon Bankoff, Los Angeles, California

F, D, and E, the vertices of the pedal triangle, are the feet of the altitudes from A, B, and C respectively.

Since $\angle ADB = \angle AFB = 90°$, D and F lie on the circumference of the circle on diameter AB. So $\angle DFA = \angle DBA$, and their complements, $\angle DFC$ and $\angle DAB$, are equal.

Hence triangles CDF and CAB are (inversely) similar.

In like manner we find that triangle CAB is also similar to triangles AED and EBF.

In similar triangles AED, EBF and FCD,

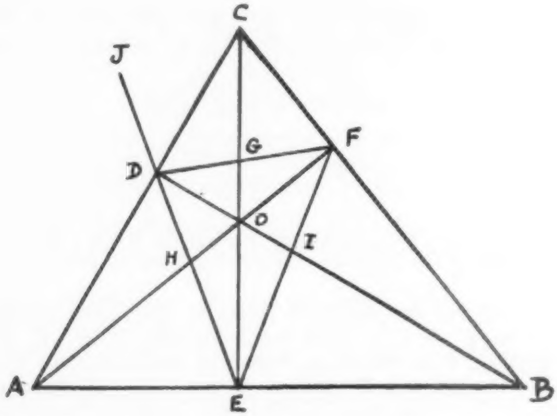
$$\angle DEA = \angle FEB$$

$$\angle BFE = \angle DFC$$

$$\angle CDF = \angle EDA.$$

By extending any side of the pedal triangle and noting the equality of vertical angles, the proposition is proved.

EDITOR'S NOTE: It was pointed out by Mr. Berndt and Mr. Trigg that this proposition is only true if triangle ABC is acute and if the orthic triangle is the pedal triangle of the ortho center of triangle ABC.



Solutions were also offered by Richard L. Berndt, Valparaiso, Indiana; P. L. Howe, Angwin, California; C. W. Trigg, Los Angeles City College; Richard H. Bates, Milford, N. Y.; Margaret Joseph, Milwaukee, Wisconsin; Walter R. Warne, Syracuse, N. Y.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2342. *John Hewett, Upper Canada College.*

2344. *George Steiner, David Yule, Ken Watson, Upper Canada College.*

2352. *Charles Finnita, Larkspur, California; Walter Germond, Philadelphia.*

2335. *Miller Peck, Pittsburg.*

2350. *Nathaniel Grossman, Aurora, Ill.*

PROBLEMS FOR SOLUTION

2365. *Proposed by Dwight L. Foster, Florida A&M.*

Show that

$$\frac{1}{2}+\frac{1\cdot 3}{2\cdot 4}\cdot\frac{1}{4}+\frac{1\cdot 3\cdot 5}{2\cdot 4\cdot 6}\cdot\frac{1}{4^2}+\frac{1\cdot 3\cdot 5\cdot 7}{2\cdot 4\cdot 6\cdot 8}\cdot\frac{1}{4^3}=\frac{4\sqrt{3}}{3}(2-\sqrt{3}).$$

2366. *Proposed by C. W. Trigg, Los Angeles City College.*

A vertex of a triangle, the point of contact of the ex-circle relative to this

vertex with the opposite side, and the remote extremity of the diameter of the in-circle perpendicular to this side are collinear.

2367. *Proposed by Merton T. Goodrich, Keene Teachers College, Keene, N. H.*

Find the formula for the area of any quadrilateral, given the length of one side, the altitudes from the two vertices to this side, and the projections on this side of the two adjacent sides. The given side may be extended if necessary to meet the altitudes and include the projections.

2368. *Proposed by Hugo Brandt, Chicago.*

If rectangle $ABCD$ is circumscribed about the ellipse $x^2b^2+y^2a^2=a^2b^2$ and if the points of tangency are S on AB, T on BC, U on CD, and V on DA, show that SV and TU are parallel to diagonal BD.

2369. *Proposed by Dewey C. Duncan, E. Los Angeles Jr. College.*

If x and y are unequal rectangular Cartesian coordinates, then $(x+y)/2$ always exceeds $\sqrt{xy}$. If x, y, z are homogenous rectangular Cartesian point coordinates, show that

$$\frac{x+y+z}{3}>\sqrt[3]{xyz}.$$

2370. *Proposed by W. B. Goodrich, Dallas.*

An early Texas pioneer staked out his square domain by a rail fence 7 rails high. Each rail 8 feet and 3 inches long touches adjoining rails at centers of supporting posts, stationed along the perimeter 8′3″ from center to center. The number of rails in the fence equals the number of acres in the field. Find the dimensions.

BOOKS AND PAMPHLETS RECEIVED

ELEMENTS OF ALGEBRA FOR COLLEGES, by Professor V. B. Caris, *Ohio State University, Columbus, Ohio.* Cloth. Pages vi+307. 15.5×23 cm. 1953. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.30.

THE PRINCIPLES OF LINE ILLUSTRATION, by L. N. Staniland, A.R.C.S., D.I.C., A.R.W.A. Cloth. Pages xii+212. 13.5×21.5 cm. Harvard University Press, Cambridge, Mass. Price $5.00.

GENERAL BIOLOGY, Third Edition, by Leslie A. Kenoyer, Ph.D., *Head Department of Biology, Western Michigan College;* Henry N. Goddard, Ph.D., *Late Professor of Biology, Western Michigan College;* and Dwight D. Miller, Ph.D., *Associate Professor of Zoology, University of Nebraska.* Cloth. Pages viii+662. 15×23.5 cm. 1953. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $6.00.

PLANE TRIGONOMETRY WITH TABLES, Second Edition, by Donald H. Ballou Ph.D., *Middlebury College,* and Frederick H. Steen, Ph.D., *Allegheny College.* Cloth. Pages vi+150+10+84. 14×22.5 cm. 1953. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.25.

PLANE AND SPHERICAL TRIGONOMETRY WITH TABLES, Second Edition by Donald H. Ballou, Ph.D., *Middlebury College,* and Frederick H. Steen, Ph.D., *Allegheny College.* Cloth. Pages vi+205+13+84. 14×22.5 cm. 1953. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.50.

THE UNIVERSE OF MEANING, by Samuel Reiss. Cloth. Pages x+227. 13×21.5

cm. 1953. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.75.

YOU AND YOUR WORLD, by Paul F. Brandwein, *Chairman, Science Department, Forest Hills High School, New York City;* Leland G. Hollingworth, *Director of Science, Brookline Public Schools, Brookline, Massachusetts;* Alfred D. Beck, *Science Supervisor, Junior High School Division, Board of Education, New York City;* and Anna E. Burgess, *Directing Principal, Formerly Supervisor of Elementary Science, Board of Education, Cleveland, Ohio.* Cloth. Pages vi+407. 16×23.5 cm. 1953. Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York 17, N. Y. Price $2.96.

THE SCIENTIFIC ADVENTURE. ESSAYS IN THE HISTORY AND PHILOSOPHY OF SCIENCE, by Herbert Dingle, *Professor of History and Philosophy of Science, University College, London.* Cloth. Pages ix+372. 13.5×21.5 cm. 1953. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

PLANE GEOMETRY, by Virgil S. Mallory, *Professor of Mathematics and Instructor in the College High School, State Teachers College, Montclair, New Jersey,* and Chauncey W. Oakley, *Head of the Department of Mathematics, High School, Manasquan, New Jersey.* Cloth. Pages x+468. 13×20.5 cm. 1953. Benj. H. Sanborn and Company, 221 East 20th Street, Chicago 16, Ill.

AN INTRODUCTION TO STATISTICS, by Charles E. Clark, *Associate Professor of Mathematics, Emory University, Georgia.* Cloth. Pages x+266. 14.5×23 cm. 1953. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $4.25.

ANALYTIC GEOMETRY AND CALCULUS, by Lloyd L. Smail, Ph.D., *Lehigh University.* Cloth. Pages xiv+644+lxx. 14×21.5 cm. 1953. Appleton-Century-Crofts, Inc., 35 West 32nd Street, New York 1, N. Y. Price $5.50.

ASTRONOMY FOR EVERYMAN, Edited by Martin Davidson, B.A., D.Sc., F.R.A.S. Cloth. Pages xviii+494. 12×19 cm. 1953. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York 10, N. Y. Price $5.00.

TEXTBOOK OF BOTANY, Revised Edition, by E. N. Transeau, *Emeritus Professor of Botany and Plant Pathology, Ohio State University;* H. C. Sampson, *Professor of Botany and Plant Pathology, Ohio State University;* and L. H. Tiffany, *William Deering Professor of Botany, Northwestern University.* Cloth. Pages xi+817. 14.5×23.5 cm. 1953. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $6.00.

FATHER OF AIR CONDITIONING (WILLIS HAVILAND CARRIER), by Margaret Ingels. Cloth. 170 pages. 13.5×21 cm. 1952. Selvage and Lee, 1 East 43rd Street, New York 17, N. Y. Price $2.50.

PLANE GEOMETRY, Revised Edition, by Rachel P. Keniston and Jean Tully, *Stockton Unified School District, Stockton, California.* Cloth. Pages vii+392. 18×25 cm. 1953. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.88.

SYNCHROS SELF-SYNCHRONOUS DEVICES AND ELECTRICAL SERVO-MECHANISMS, by Leonard R. Crow, *Educational Specialist in Design and Development of Training Aids for Teaching Electricity.* Cloth. Pages x+222. 13.5×21.5 cm. 1953. The Scientific Book Publishing Company, 530 South 4th Street, Vincennes, Ind.

THE TEACHING OF SECONDARY MATHEMATICS, by Claude H. Brown, *Professor of Mathematics, Central Missouri State College.* Cloth. Pages xi+388. 13.5×21 cm. 1953. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $4.00.

A TEXTBOOK OF GENERAL BOTANY, Fifth Edition, by Gilbert M. Smith, *Stan-*

ford University, Edward M. Gilbert, George S. Bryan, Richard I. Evans, and John F. Stauffer, *University of Wisconsin*. Cloth. Pages x+606. 15×23 cm. 1953. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $6.25.

The River Horse, by Nina Ames Frey. Cloth. 150 pages. 13×20.5 cm. 1953. William R. Scott, Inc., 8 West 13th Street, New York 11, N. Y. Price $2.50.

Fundamental Concepts of Geometry, Preliminary Edition, by Bruce E. Meserve, *University of Illinois*. Paper. 296 pages. 20.5×28 cm. 1953. Addison-Wesley Press, Inc., Cambridge 43, Mass.

The Fifty-Second Yearbook of the National Society for the Study of Education, Part I, Adapting the Secondary-School Program to the Needs of Youth, Prepared by the Yearbook Committee, William G. Brink(Chairman) and Others. Paper. Pages xiii+316+vi. 14.5×22 cm. 1953. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $2.75.

The Fifty-Second Yearbook of the National Society for the Study of Education, Part II, The Community School, Prepared by the Yearbook Committee, Maurice F. Seay (Chairman) and Others. Paper. Pages xii+292+lxxii. 14.5×22 cm. 1953. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $2.75.

BOOK REVIEWS

Discovering Numbers, 346 pages; Learning Numbers, 346 pages; Exploring Numbers, 376 pages; Understanding Numbers, 378 pages, by Leo J. Brueckner, Elda L. Merton and Foster E. Grossnickle. 15.5×21.5 cm. 1952. John C. Winston Company, 623–629 South Wabash, Chicago, Ill.

These books are four of a series of six designed for grades three through eight. They are definitely not a mere revision of previous texts by the same authors. The organization has been changed, the illustrations are entirely different, the verbal problems are new, color has been added and several new motivational devices have been included. It can be safely said that the books are equivalent to an original writing but at the same time capitalizing on the previous experience of the authors.

The coloring is pleasant but not overdone. Much use is made of heavy and light type both in print, pictures and symbolic representation. Each chapter is introduced with a full page colored picture. These pictures are appropriate to the pupil level and are used in the development of content material.

The texts are all written to the student and many questions are asked. Some of these questions are designed to motivate thinking on the part of the pupil and have no specific answers. The texts are filled with illustrative material such as pictures, symbols and representations of all kinds to aid the pupil as he develops concepts of quantity. Even in the sixth grade text there are only a few pages where some visual representation of quantity does not appear. The first book assumes very little previous knowledge of number. But the use of this text as a first study of number would require some supplementary work by the teacher.

Each volume of the set does very well in reorienting the pupil after the summer vacation. There is continued emphasis on continuity by page reference to previous work which is related to the work at hand. Zero is considered with much more emphasis than in many texts. Its meaning is developed in its rightful place in the number system and it is not relegated to the role of "place holder" only as is so often the case.

Place value is stressed continually throughout the series and illustrations using the "pocket board" or "place value board" are numerous. There is some introduction to estimation of results before calculation. This is supplemented with exercises where the pupil points out the error.

Fractions and operations with fractions occupy a considerable portion of the texts. Here again many pictorial representations of quantity are used. The different meanings of fractions such as, part of a whole, part of a group, a ratio, and an indication of division are clearly analyzed by use.

In the work dealing with measurement, the approximate nature of measurement is stressed. However, when measured lengths are used to find area no consideration is given to this concept, which has been carefully developed. It seems to the reviewer this is a serious omission.

There is a great deal of social mathematics in the set but the social situation is only the vehicle used to carry the mathematical principle. The social situations are usually those familiar to pupils of the age who would be using the particular text concerned.

Very good use is made of school situations where the concept of quantity is involved. Such things as cost of books, desks, other room equlpment, and general costs of activities connected with school life are used as vehicles to develop mathematical principles and concepts.

The vocabulary is suitable for the pupils for whom it is intended. The content of each text follows the order of that recommended by most leaders in the field of elementary arithmetic. The basic principles and facts are presented in all four texts but in a spiral arrangement of frequency which should provide for maintenance and increased understandings.

There are one or two spots where the reviewer believes some confusion may result due to apparent inconsistency of the description and its implementation. As an illustration, on page 14, in *Learning Numbers* there are two statements in black type. "In this problem Andy takes two smaller groups and puts them together to form a larger group." Six lines below appears this statement: "In addition problems, something happens so that there are more than there were. You add to find the total number." The difference is evident to the teacher but if the pupil takes both statements seriously he may be confused by the seemingly opposite definitions. A similar example is found in *Understanding Numbers*, page 37, where three ways of expressing remainders are shown and two of them appear to be exactly alike—$2\frac{1}{2}$ and $6\frac{2}{3}$, the $\frac{1}{2}$ actually being the amount divided and given while the $\frac{2}{3}$ is only the indicated division. It is true the pictures at the top of the page aid in clarifying this but it seems to the reviewer a little too subtle for the sixth grade pupil. These are only minor points that would be no handicap at all to the good teacher.

The special features of the books include an Arithmetic Workshop of drill exercises in the back of the text with cross page references to where such drill may be needed in the context. There are lists for self-help, progress tests, vocabulary tests, suggested games to play for increasing proficiency, practice tests, diagnostic tests, special topics for pupils who do not need extra practice, rating scales for solving verbal problems, lists of questions on understanding of number and its use, as well as discussion on study methods and techniques. The books are well indexed.

Although these authors have consistently produced high caliber books, this set seems to have topped the previous publications.

PHILIP PEAK
Indiana University
Bloomington, Indiana

WAVES AND TIDES, by R. C. H. Russell, M.A., and Commander D. H. Macmillan, R.N.R. (Rtd.), F.R.I.C.S., Assoc. I.N.A., *Hydrographic Surveyor to the Southampton Harbour Board.* Cloth. 348 pages. 13.5×21 cm. 1953. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

This volume consists of two books, one on waves by Mr. Russell and the other on tides by Commander Macmillan. To most of us the two topics seem closely related but in many respects they are far apart. These books will give to many a new view of ocean forces. Both books are well illustrated by diagrams, graphs,

and some excellent reproductions of photographic plates. Each book has its own page of symbols, which must be carefully noted, as e. g. H, for wave height, has a different meaning in the two books. An excellent short list of references follows each chapter. Both books are largely special applications of physics to the action of the waters of the sea, hence discussions of reflection, diffraction, and refraction read off easily by those trained in physics but both discussion and diagrams will require more attention by others. Each chapter is followed by an excellent short set of references, mostly from British or American authors but a few from the French and German are included. The discussion of tidal theory is exceptionally well done. Many charts, diagrams, graphs and plates are used to illustrate and explain. A minimum amount of mathematics is used to explain the tide oscillations. Short appendices to each part give some of the mathematical derivations used.

G. W. W.

Mental Prodigies, by Fred Barlow. Cloth. 256 pages. 12.5×18.5 cm. 1952. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

If you are interested in the exceptional brilliance in computation exhibited by some children who are only mediocre or even half-witted in ordinary matters, this is a book you will enjoy. It is a rare book, in fact the reviewer does not know of another in its class. The sub-title gives a better description than anything else that can be written, so it is here quoted: *An Enquiry into the Faculties of Arithmetical, Chess and Musical Prodigies, Famous Memorizers, Precocious Children and the Like, with Numerous examples of "Lightning" Calculations and Mental Magic.* Section I gives a brief history, often about all that is known, of many arithmetical prodigies, with attempts to tell how they accomplished their phenomenal results. Section II describes chess and musical prodigies and gives a chapter on precocity and genius. Section III is devoted to famous memorizers and how they accomplished their results. Section IV gives the mental magic involved in the solution of numerical problems, a section on lightning calculations, another on magic squares, and still another on other arithmetical recreations. Section V deals with the psychological aspects and gives some of the author's speculations and conclusions.

G. W. W.

What Makes the Wheels Go Round, New Revised Edition, by Edward G. Huey. Cloth. Pages viii+176. 13×20.5 cm. 1952. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.00.

This is a new edition of a book that first appeared in 1940, a book on some of the interesting topics of physics. Physics is a subject usually studied in high school or college, but here is a book for the elementary school boys and girls. Of course it does not attempt to tell all of physics, as many writers of high school texts try to do. But it tells a little about many of the interesting topics in heat, light, electricity, sound, and mechanics. These things are told without resort to mathematics and laboratory equipment. Of course, to put this in language that children can fully understand, sometimes erroneous statements are made; but most of these errors are errors of omission, as the statement, "A prism is a three-sided figure. . . ." But the drawing showing the use of a prism gives the student the idea intended. Elementary science teachers should try out this book. Children will read it and ask for more. So, be prepared for their questions.

G. W. W.

Science in Everyday Life, by Ellsworth S. Obourn, *Head of Science Department, John Burroughs School, Clayton, Missouri;* Elwood D. Heiss, *Professor of Science, New Haven State Teachers College, New Haven, Connecticut;* and Gaylord C. Montgomery, *Instructor of Science, John Burroughs School.* Cloth.

Pages ix+612. 17×23.5 cm. 1953. D. Van Nostrand Company, Inc. 250 Fourth Avenue, New York 3. Price $3.80.

If you have entered science teaching in the past ten years, you immediately recognize the first two authors. Their science methods text—*Modern Materials and Methods for Teaching Science* is well known and widely used. The third author is a classroom teacher and will have the classroom teacher's insight into presentation of the science materials in the book.

The outside cover of this high school general science text is very attractively made with a picture of a dam spillway. By accident some water was spilled on the cover. It wiped off without blurring or smudging. A minor point, but a durable cover is important.

The text consists of nine units. These are broken down into three or four chapters each. Each chapter consists of three to five problems. These are stated in the form of questions. There are 27 chapters. There is a glossary and index at the end. Each unit starts with a full page illustration. Then a section titled "Looking Ahead" is a unit preview. Each chapter has a short introduction and listing of the problems in that chapter. Throughout the chapters are many experiments called "experiences." Each of these starts with a question to be solved. There are questions at the end of each problem and each chapter.

Emphasis is placed on problem solving throughout the book. The first unit "We Live in a World of Science" gives the student a very thorough introduction to the scientific method. In a very unique way this text carries the problem solving in each unit. At the end of each chapter is a "Practice in Problem Solving." These will be very interesting and stimulating to the class for either group or individual work.

The text differs from most recent texts in that they keep Franklin's current flow direction. There is a paragraph explaining Franklin's Mistake, but nothing is done to correct it in the text or diagrams.

The line drawings and pictures are pertinent. There are several full page color pictures. The format is double column. The use of full width illustrations in the center of the page causes some distraction in reading the text.

A Teacher's Guide and Key are available. A workbook is in preparation.

E. Wayne Gross
University School
Bloomington, Indiana

Evolution and Human Destiny, by Fred Kohler, Cloth. Pages 120. Hallmark-Hubner Press, Inc., Philosophical Library, 15 E. 40th Street, New York. 1952. Price $2.75.

This recent addition to the Philosophical Library is not a book for quick, light reading. It is different from the usual run of works on evolution. The main theme revolves about the importance of entropy or the randomness of a system and extropy its reciprocal, in the progress of evolution. The evolution from the simplest of substances to the most complicated of present animal societies supposedly owe their states to the machinations of extropy and entropy.

It seems that almost any situation can be explained with these unusual terms, and it is to no one's disadvantage when either state is in effect dominant. One might say that no matter what happened or what evolution may bring about, it is all for the best and it was due to entropy or extropy.

The author begins with the phenomena of orderliness in terms of the primitive forms of life, their death, reproduction and survival, gradually working up to the multicellular organisms. This discussion gradually tends to the philosophical and social implications of the theory stressing among other things, the importance of language, writing and specialization in colony formations, as factors in evolution.

Anyone contemplating the possibility of life on other planets would find this little book quite interesting as it lends encouragement to the idea. It contemplates some possibilities of future life here on earth also.

The book on the whole is very thoughtprovoking and is a step forward in man's attempt to logically explain biological phenomena. It would be a profitable addition to a science educator's personal library as it could be used as a basis for discussion among college biology students and seminar groups.

It might also serve to clarify or fortify a few questionable positions in the minds of those educators who have occasion to discuss the subject of evolution in high school classes. For those who wish to pursue the subject further, there is a short selected bibliography included. The book should be read to be fully appreciated.

JOHN D. WOOLEVER
Mumford High School
Detroit, Michigan

YOUR COMMUNITY'S HEALTH, by Dean F. Smiley, *Formerly Professor of Hygiene and Preventive Medicine, Cornell University,* and Adrian G. Gould, *Formerly Assistant Professor of Hygiene and Preventive Medicine, Cornell University.* Cloth. Pages xiv+454. 1952. Macmillan Company. $5.50.

This new book is a revision of *Community Hygiene* which many educators have been using for years in their classes, and have in their reference libraries. It is not a summarizing type of book but is more of a challenging type of text attempting to arouse its reader to a realization that community health is a continually changing and challenging problem.

It covers the usual community health problems and is divided into five sections. There is a very short historical introduction with the second section devoted to the common health hazards of our environment. The third unit deals with the community's attack on certain specific diseases, followed by the needs of specific groups such as school children, rural dwellers and the aged.

Many new and heretofore neglected health problems in other texts are stressed, such as polluted city air, inadequate housing, occupational hazards, geriatrics, mental health and directed recreation.

Although drug addiction is included, it is disappointingly short. There is a fairly good treatment of sex hygiene, including data from Kinsey's report and a discussion of prostitution. The latter would probably be the first objection many high school administrators would have, to using the book.

The latest developments in international public health are well taken and even the problems facing the drug industry in producing the latest miracle drugs for the clamoring public are sympathetically explained.

In discussing patent medicines, sometimes a touchy subject, revelations such as the fact that a $.20 pound of clay and water being as useful as some well known ten dollar beautifying creams, is one of its many textbook novelties.

The final section is devoted to the agencies that work for the citizens' Health and Welfare. This specific topic is important especially to those future citizens who are ignorant of the services offered to them and who support them through their taxes but don't know enough about the agencies to take advantage of their services. Many students eventually will have a need for these services and should take advantage of what they have to offer.

Both authors have had a wealth of experience in matters of health as it relates to masses, having been in the Army and Navy Medical Corps, and the book gives evidence of their knowledge thus gained.

There are several fold-ins including a useful communicable disease chart. Diagrams, maps, charts and excellent photographs are plentiful. Quality of paper and type could be rated as excellent.

There are none of the usual post chapter tests or exercises but there are suggested readings and an extensive list of sources of motion pictures on health subjects.

It is recommended for able high school or college classes either as a text or reference. It is easy to read but would be a little too comprehensive for the average high school student in general health classes.

JOHN D. WOOLEVER

MORE MODERN WONDERS, by Captain Burr W. Leyson. Cloth. Pages 192. 1952. E. P. Dutton & Co., Inc. New York. Price $3.50.

Another volume from the pen of Captain Leyson has just been published, one of many that describes and explains various inventions and devices that the average man uses daily or takes for granted in his daily activities. This time he begins with arms and ammunition, spending five chapters on the subject. Other chapters include the operation of hydraulic transmissions, weather instruments, atomic powered submarines and the world wide phonograph. The author does not attempt to explain all modern wonders as might be inferred from his popular book titles, but the ones he has chosen are very thoroughly and satisfactorily taken.

Hunters and marksmen will find the sections devoted to arms very interesting and it would also be of interest to others to discover among other facts, that the fully automatic pistol which we hear so much about, is illegal to own and even the military does not use them because they are inaccurate and ineffective, except under unusual circumstances.

It was fascinating to follow the history of locks and locking devices from the simple door bar to the famous Yale door lock which has become synonymous with dependability the world over.

Throughout parts of the book however, one seems to get the feeling that he might be reading a manufacturer's brochure. At least this is true in the chapters devoted to the two subjects mentioned, locks and firearms.

Perhaps this would not be as noticeable to the average reader as much as it might the educator who is used to books that rarely mention a manufacturer's patented and nationally advertised product. This should not deter anyone from using or reading the book however, as its merits far outweigh any commercial promotions which I'm sure are not intentionally implied.

The style in which the book is written is simple and concise. The explanations and descriptions are clear and even the inner workings of an anemometer is made fascinating reading.

The diagrams and photographs are exceptionally clear and the latter were well planned to illustrate a book of this type. One photo includes an early recording scene which shows the ancestor of the modern microphone viz: a horn projecting through a hole in the wall.

The content would be of particular interest to sportsmen and hobbyists. It would also be of value to a general science library or high school library not only as a reference book in physics but also for general reading for mechanically inclined adolescents.

This book compares favorably with those that preceded it. If the Captain has ever considered writing a text, particularly for physics, and if it is written in any way like his latest book, I'm sure even the least scientifically inclined students would profit greatly from it.

JOHN D. WOOLEVER

EVOLUTION IN THE GENUS DROSOPHILA, by J. T. Patterson and W. S. Stone, *Professors of Zoology, University of Texas.* 610 pages. 14×21 cm. The Macmillan Company, New York. Price $8.50.

Anyone who has touched upon the study of biology knows the name Drosophila and knows of its laboratory significance to the study of genetics. In this volume two top-ranking geneticists give the evidences of evolution as revealed by the fruit fly. It is a new approach inasmuch as most studies to date have utilized morphology, embryology, paleontology, or natural history. Drosophila lends itself well to such a study because of the many and intensive studies which have been made of the genus and because the genus has split into several subgenera and many species which have been subject to study. The book contains the following chapter headings: the genus Drosophila; geographical distribution and speciation; chromosome evolution in the genus Drosophila; salivary gland

chromosomes; gene variation, selection, and genic balance; isolating mechanisms; the insemination reaction and other isolating mechanisms; hybrids and hybrid sterility; evolution in the virilis species group; and comparisons and conclusions. As the above indicates, the book would be of little use to anyone who has not the proper background for a highly technical approach to the problem, but as such, it is certainly a significant contribution to our knowledge of the evolutionary processes.

George S. Fichter
Oxford, Ohio

Soil Microbiology, by Selman A. Waksman, *Professor of Microbiology, Rutgers University*. Pages vii+356. 14.5×22.5 cm. John Wiley & Sons, Inc., New York. Price $6.00.

This is a book which has as its purpose "to survey the nature and abundance of microorganisms in the soil, to review the important role that they play in the soil processes, and, so far as possible, to show the relation between them and soil fertility." It does so in an informative style which is also, in most places, highly technical. The importance of soil science, however, makes the inclusion of this book in any reference library highly recommended. The author has brought up to date the material which he used in two previous books: *Principles of Soil Microbiology* and *The Soil and the Microbe*. Dr. Waksman may be best remembered, of course, for his discovery of streptomycin.

George S. Fichter

Between Pacific Tides, by Edward F. Ricketts and Jack Calvin. Revised by Joel W. Hedgpeth. Cloth. Pages xii+502. 14.5×23 cm. Third Edition, 1952. Stanford University Press, Stanford, California. Price $6.00.

Between Pacific Tides is, first of all, a book of marine biology, a careful accounting of the habits and habitats of the invertebrates which live along the rocky shores and in the tidal pools of the Pacific Coast. The authors describe the animals by their ecological grouping rather than by their phylogenetic relationships.

The senior author, Edward F. Ricketts, was a self-made biologist. His college training only sketched the subject, although it is significant to note some of his study was under the guidance of the distinguished zoologist, W. C. Allee. In the early 1920's, Ricketts moved to the west coast where he became a partner in a biological supply business; this gave him opportunity and bread-and-butter excuse to become intimately informed of the seashore and its animal life. As a personality, he was unusual, magnetic, and dynamic, and as Dr. Allee said of him, his ways "tended sometimes to be disturbing, but were always stimulating." Perhaps only a noteworthy sidelight when considering the book as an informational sourcebook but certainly an interesting one is the fact that Ed Ricketts was "Doc," the principal character in John Steinbeck's *Cannery Row*.

"This book of Ricketts and Calvin," wrote John Steinbeck in the foreword, "is designed more to stir curiosity than to answer questions. It says in effect: look at the animals, this is what we seem to know about them but the knowledge is not final, and any clear eye and sharp intelligence may see something we have never seen. These things, it says, you will see, but you may see much more This is a book for laymen, for beginners, and, as such, its main purpose is to stimulate curiosity not to answer finally questions which are only temporarily answerable."

This third edition (Ed Ricketts was killed in an automobile accident in 1948, and Jack Calvin, who was literary collaborator and photographer for the first edition, did not wish to undertake himself the chore of bringing the edition up-to-date) was prepared by Joel Hedgpeth, of the Scripps Institute of Oceanography.

George S. Fichter

INTRODUCTORY MYCOLOGY, by John Alexopoulos, *Professor of Botany and Plant Pathology, Michigan State College.* Cloth. Pages xiii+482. 14.5×23 cm. 1952. John Wiley & Sons, Inc., New York. Price $7.00.

This is a mycology textbook, an organized presentation of the available information on structure and classification of the fungi. The increased attention being given the fungi as a result of the discovery of antibiotics, the recognition of the roles which fungi play in allergies and in the parasitic diseases of man, and the accelerated study given the genetics and biochemistry of the group—these have brought on specialized college course work in mycology and hence the need for a textbook on the subject. The book is not a complete coverage of the fungi but purports to give the student an answer to "what the fungi are and how they affect us."

In the chapter treatments of the various fungi groups, the material is organized in a systematic approach along a pattern such as indicated here: an introduction, showing the relationship of the group to other fungi; occurrence and importance to man; somatic structures; reproduction—asexual and sexual; classification; orders, families, genera, and species; summary and general remarks about the group; references.

The book also contains a glossary of the mycological terms used in the text, and there is a thorough indexing. Numerous drawings accompany and explain the text material.

GEORGE S. FICHTER

FUNDAMENTAL PRINCIPLES OF FINANCIAL MATHEMATICS, by Merrill Rassweiler and Irene Rassweiler, *University of Minnesota.* Cloth. Pages vii+254. 6×9 inches. 1952. The Macmillan Company. Price $3.25.

This text was written for first year college students who have limited training in Mathematics. Its contents are extensive. In addition to interest and annuities and their application, it contains material on various kinds of insurance, taxation, depreciation, buying and selling.

Most of the chapters begin with an introduction showing the need of the material to be considered. This is followed by careful definition of terms and a discussion of their application to business. Each mathematical process is explained in detail, and illustrated by a worked example. Lists of problems providing drill and showing application are given. Those problems are numerous and well selected. Some tables are provided in the text, but a separate set of tables will be needed by the student. The use of tables and interpolation is explained.

One distinguishing feature of this text is the exclusive use of arithmetic rather than formulas. The author states that this is desirable on account of the limited mathematical ability of the students, and also that "we have often observed that the use of algebraic formulas have often confused instead of clarified the basic operations with financial tables." This reviewer does not accept this hypothesis and believes that a few basic formulas would help the student to understand many processes, and that students can learn to use these formulas. Since the mathematical processes are so well explained and so easily located, this text should be useful not only to students, but to any one who has an occasional need for some knowledge of mathematics of finance.

HILL WARREN
Lyons Township Junior College
La Grange, Illinois

BASIC SKILLS IN MATHEMATICS, by H. Vernon Price and Lloyd A. Knowler, *The State University of Iowa.* Pages viii+249. 1952. Ginn and Company, New York. Price $3.25.

The content in this text is based on a course designed to meet two objectives of the College of Liberal Arts at the State University of Iowa. These objectives are to provide an opportunity for the student to acquire basic skills in mathematics

necessary to meet the common demands of various college programs and to provide the skills needed for intelligent understanding of the quantitative aspects of every day living. The authors make a genuine effort to develop understanding of concepts and processes as well as developing skill. The explanatory material is written to and for the student. This is followed by exercises for practice purposes.

The topics selected are almost identical with those in the Check List of the Commission on Post-War Plans of the National Council of Teachers of Mathematics. They are divided into eleven chapters under the following headings: Whole Numbers and Fractions; Lines, Angles, and Planes; Letters as Generalized Numbers; Positive and Negative Numbers; Linear Equations; Properties of Geometric Figures; Ratio, Proportion, and Variation; Percentage; Elements of Finance; Graphs; and Statistical Concepts.

Two features of this course and text strike the reviewer as interesting. First, the fact that a state university needs to offer such a course in its college of liberal arts is evidence that many high school pupils are not achieving the objectives we believe are important at that level. Second, the choice of topics emphasizes the significance and importance of the items in the Check List of the Commission on Post-War Plans. The text will be of interest to instructors of mathematics in both high school and college and particularly to those concerned with mathematical competence for all students.

GEORGE E. HAWKINS

PRACTICAL MATHEMATICS, New Fourth Edition, by Claude Irwin Palmer and Samuel Fletcher Bibb, *Associate Professor of Mathematics, Illinois Institute of Technology*. Pages xii+769. 1952. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $4.50.

This one volume edition incorporates the content of the former four volumes of Practical Mathematics originally written by the late Dean Palmer for his evening school classes. Students in these classes were engaged in practical pursuits, and the materials gathered to meet their needs were very practical in nature.

In the present revision the data in all exercises have been brought up to date. Some new material has been added, presentation has been simplified, explanations expanded, and more sample problems solved.

Each of the four parts of the book are independent and may be used alone. Part I deals with Arithmetic; Part II, Geometry; Part III, Algebra and Logarithms; and Part IV, Trigonometry. In geometry the authors attempt to state definitions in such a way as to give a clear idea of the term, and they try to present geometric principles in such a way that their reasonableness will be apparent. The content is not concerned with deductive logic and proof. Those parts of trigonometry are emphasized that can be used directly in solving practical problems and little attention is given to those parts dealing with analysis.

This book contains a wealth of problem material in the exercises, many of them very practical in nature and not found in the usual textbook. Answers are given to most problems. Four place tables are included. The book should appeal to many users. The adult who wants to review some of his mathematics will find it very helpful. As a text it is suitable for vocational schools, technical institutes, apprentice schools, and terminal courses in junior college. The teacher of high school mathematics will find it an excellent source for applications.

GEORGE E. HAWKINS

ORGANIC CHEMISTRY, by Melvin J. Astle and J. Reid Shelton, both of *Case Institute of Technology*. Cloth. Pages x+771, 15 by 23.5 cm, 1952. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $7.50.

This is a well written text in Organic chemistry; the authors have written with clarity, and the publishing company has done an excellent job both with respect

to paper used and the size of print. The text includes ample material for a year's course in beginning organic chemistry.

In the preface the authors give the following as their main objectives:

"1. To include all essential principles and reactions so as to give the student a thorough training in the fundamentals of organic chemistry.

"2. To interpret organic reactions in terms of modern electronic theories which enable the student to recognize the fundamental mechanisms which relate the many types of organic reactions.

"3. To give the student an appreciation of the scope of the reactions discussed, e.g., whether the reaction is of importance mainly in the laboratory or whether it is used in the preparation of industrially important compounds."

The authors have followed the classical order of topic treatment. The first sixteen chapters provide a rather ample coverage of the aliphatic compounds. This is followed by chapters dealing with proteins, aliphatic sulfur compounds, carbohydrates, and alicyclic compounds. Chapters 22 through 29 inclusive give a very complete treatment of aromatic chemistry. The last five chapters treat in order, heterocyclic compounds, alkaloids, terpenes, steroids, and high polymers. The chapter on high polymers gives some excellent chemistry on recent industrial developments in plastics and synthetic fibers. The chemistry of one of Dupont's most recent fibers, namely "dacron," is included.

The reviewer feels the authors have accomplished the three objectives outlined in their preface. The book deserves careful examination by anyone contemplating a new text in introductory organic chemistry.

GERALD OSBORN
Western Michigan College of Education
Kalamazoo, Michigan

THE COMPOSITION AND ASSAYING OF MINERALS, by J. S. Remington and Wilfred Francis. Cloth. Pages viii+128, 21.5 by 14 cm. 1953. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $5.50.

This is not a book which would serve as a complete guide to mineralogy because little emphasis is given to crystallography or to such properties as hardness or density; rather the emphasis is on methods of chemical analysis of minerals.

Both qualitative and quantitative methods of analysis are given or the following elements so often found in naturally occurring rocks and minerals: lead, mercury, bismuth, copper, cadmium, arsenic, antimony, tin, iron, aluminum, chromium, titanium, zinc, molybdenum, manganese, nickel, cobalt, vanadium, barium, strontium, calcium, magnesium, potassium, sodium, chlorine, phosphorous, silicon, and sulfur. In addition, consideration is given to some of the elements whose minerals are not so abundantly distributed on the earth's crust, namely, silver, gold, platinum, tungsten, and uranium. In the main, solution methods of analysis are used. Very little attention is given to blow-pipe methods.

Both geologists and chemists should find the book useful.

GERALD OSBORN

WATER, ITS PROPERTIES, CONSTITUTION, CIRCULATION AND UTILIZATION BY MAN, by Sir Cyril Fox, D.Sc., F.G.S. Cloth. 25 Plates and 4 Figures. Pages vii+148. 15.2×25.4 cm. 1952. Philosophical Library, New York, N. Y. Price $8.75.

This is the first of a series of books on Water Treatment; Purification and Disposal of Sewage; Water Supply of Towns etc. having to do with various aspects of water supply. The readers to be served, it appears, are sanitary and civil engineers and that segment of the lay-public under whom these technical specialists are to work. The author briefs his presentation "to deal with the subject as simply as possible without reducing the extent of the field covered but avoiding elaborate scientific details.

The author is an Englishman, "lately director, Geological Survey of India,

(and formerly having published) Engineering Geology, Geology of Water Supply and other works on economic and engineering geology." This explains why his descriptions and pictorial specifics "are taken as far as possible from the English countryside or around the coasts and seas of the British Isles." "Most of the storage dams which are reproduced (however), are from the great schemes of land-reclamation in the United States of America."

The three general divisions are headed: I, Natural History of Water; II, Work Done by Water and III, Utilization of Water. Each of these has three chapters. Under I are considered: Constitution; Distribution and Circulation of Water. Under II are listed: Surface Erosion; Underground Action and Sediment Deposition. Part III is less specific in its sub-topics.

The reviewer opened this book with a sense of expectancy but was disappointed when he encountered a paragraph (page 3) on Noah's Flood dated by Archbishop Ussler's chronology. He was further disturbed to find: (page 5) dew as "droplets and drops deposited," specific heat (page 7) defined as "increase of temperature of one cubic centimeter of water"; density and specific gravity treated (page 7) as identical, "the boiling point of water at 100°C." without reference to pressure etc. Measurements units seem to be used without rhyme or reason, grammes or grains, metric or English linear units. "Chemical characteristics of water" turns out to be really the Chemical Characteristics of Water Solutions and not pure water.

The book is a bit heavy in statistical information but fortunately specific references to sources are given. The plates are from official photographs and are attractive and provided with informative though concise legends.

Some interesting excerpts would include: Heavy water's part in the research leading toward the "chain reaction" and the speculation upon the disaster to Los Angeles water supply if a sub-water atomic explosion in Lake Mead were achieved. It may come as a surprise to read that "It has always been easier to warm a room in winter than to cool it in summer, and cooling still costs from two to three times as much as heating."

In this volume is to be found a surprising spread of information on water. While for the specialist some of its offerings are a bit superficial, never-the-less it will be useful to those who keep its limitations in mind.

B. Clifford Hendricks
457 24th Ave., Longview, Wash.

The Evolution of Chemistry, by Eduard Farber, Ph.D. Cloth. 232 pages; 30 illustrations. 16×23 cm. The Roland Press Co., New York. 1952. Price $6.00.

The sub-title of this book is "A history of (chemistry's) ideas, methods and materials." The author groups his presentation under periods. Period I is headed "the emergence of chemistry as a science"; Period II. "The development of chemical systems"; Period III considers "Specialization and industrialization." The time encompassed by these divisions is: I, from oldest records to the eighteenth century; II, from late eighteenth to the late nineteenth century and III, from late nineteenth to our own time.

In the introduction the author attempts to propose a sort of philosophy of the history of science. The variables of his scheme are: man, time, place and object. These he calls the dimensions of the movement of history. He contends that "In order to give more than shadows we have to, . . . at least indicate all its four dimensions. . . . This makes the writing of history of a science particularly hard."

Footnotes, ample indices of both authors and subjects and an impressive list of "Periodicals Cited" testify to a wide range of research as background to the book's making. Quotations lifted from the writings of the pioneers in the phase of chemistry under treatment are very frequently used in the author's account of their achievements. The illustrations are, many of them, new to the history of chemistry so far as this reviewer's memory recalls.

Dr. Farber is an industrial chemist so this book would seem to be the product

of a spare time research. The fact that it has not evolved from a class room situation encourages the expectation that it may give an approach to the science's past that is less conventional and for that reason more alerting to its reader.

B. CLIFFORD HENDRICKS
Longview, Wash.

COLLEGE, GEOMETRY, Second Edition, Revised and Enlarged by Altshiller-Court, Professor Emeritus of Mathematics, University of Oklahoma. Pages xix+306. Publishers, Barnes and Noble, New York.

The year 1925 saw Professor Court's first edition of College Geometry. This might be called a red letter day for geometry in the high school. In ten years the book found its way into many colleges. In the field of teacher education it was a pioneer. Soon it became the basis for professionalized courses for teachers. High school teachers needed such a course then and far more do they need it now. This book exerted great influence not only upon teachers but also in the field of pure synthetic geometry.

So this revision is welcome. The text follows the pattern of the earlier book. The revision appears to be far better from the editorial standpoint. The diagrams are very clear. There is a great abundance of exercises, sufficient for more than a three hour course. For the real student of geometry there is a fine historical reference to many books and magazines.

The reviewer is inclined to pay great tribute to the author who blazed a way in this interesting field.

G. H. JAMISON
State Teachers College
Kirksville, Missouri

MR. WIZARD'S SCIENCE SECRETS, by Don Herbert. Cloth. 264 pages. 13.5×21.5 cm. 1952. Popular Mechanics Press, 200 East Ontario Street, Chicago, Ill. Price $3.00.

Professor Wilbur L. Beauchamp of The University of Chicago has this to say about this book: "Here is a book, however, that will give you your money's worth. If you want to do some interesting experiments with materials you usually can find at home and with apparatus you can make easily, this is the book for you. You will be amazed and so will your friends, with the 'magical' tricks you can do. Of course, science is not magic. There are certain laws which nature follows. The experiments will help you understand these laws and then to explain the 'magical' tricks." We should have space to give you more of Mr. Beauchamp's discussion. But you will want the book. Three dollars, spent in any other way, will not bring you half the fun, to say nothing about the real education you will get. It is a book filled with excellent drawings and pictures. 150 interesting experiments with practically all the apparatus you will need right in the kitchen. Just what you need to entertain and astonish your friends.

G. W. W.

SCIENCE MAGIC, by Kenneth M. Swezey, *Author of After-Dinner Science.* Cloth. Pages x+182. 14.5×23 cm. 1952. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $3.75.

This is another book of scientific magic and wonders, a little more advanced than *Mr. Wizard's Science Secrets* but put up in much the same form and having about the same purpose. Excellent pictures are given with each experiment so that, by following the instructions given, the experiment will always work, often with very startling results. Much of the apparatus can be found in any home; some must be provided from other sources. Many of the experiments are old but have been given a modern revision. It is instructive, amusing, astonishing, real fun for all ages.

G. W. W.